Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

FOR ALL POWER ENGINEERS • STEAM, ELECTRICITY AND ALL OTHER POWER ENGINEERING SERVICES

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By John H. D. Blanke

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THE PRACTICAL ENGINEER and ELECTRICIAN

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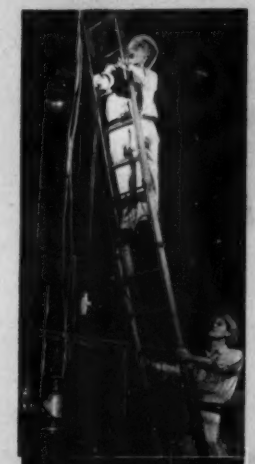

MARCH 1951

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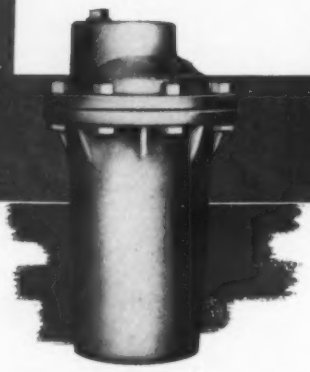

UNLIKE some devices, Armstrong traps will not pass steam, regardless of load conditions. The diagrams at the right show this conclusively. Under no-load conditions here is what happens: steam in the bucket eventually condenses due to radiation loss. When enough condensate is formed in this manner to cause the bucket to lose buoyancy and sink, the trap empties itself and the cycle repeats. The radiation loss is small—as it would be in any device of similar size. There is no steam loss!

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OPEN

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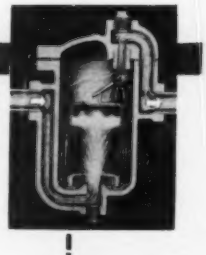
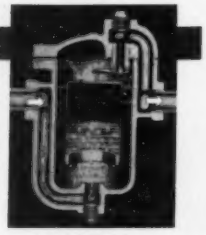


CLOSED

After condensate is discharged, steam entering bucket causes it to float, closing the valve tight. Valve remains closed until steam condenses.



SEND FOR THE 36-PAGE STEAM TRAP BOOK. It tells you how to do the best possible trapping job with facts, figures and diagrams.

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Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

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March, 1951

VOLUME 55—NUMBER 3

Notes on This Issue

Burning Gas in Modern Power Boilers

This feature section giving every detail that the power engineer needs to know about gas burning, is particularly timely. In a great many places a new supply of natural gas for boiler fuel is becoming available because of the tremendous extension of the gas pipe lines over the country during the past 3 years. Engineers who are already burning gas in power boilers usually begin in the spring of the year to make plans for burning gas during the summer when a good supply is frequently available in most sections of the country. Whether the problem is to analyze the desirability of adopting gas fuel or improving existing gas installations the engineer needs detailed operating information. This article goes right down into every detail of the gas itself, showing how much heat it contains, how much air is required to burn it, what types of boilers it can be burned in, its cost as compared with coal and oil, and tells in practical detail exactly how to operate gas burners and their associated equipment. The primary emphasis in the article is on what the boiler operator has to know and above all what he has to do in burning gas.

First U. S. All-Gas-Turbine Plant—The Edward M. Graham Station

In this station the power engineering field reaches two important steps in the progress of the gas turbine in the United States. It is the first installation of a new regenerative compound type of gas turbine generating unit in a central station solely for generation of power. It is designed to contain nothing but gas turbine units (a second duplicate unit is now on order). However, this article describes the new unit and gives a great many of the interesting details of construction of the gas turbine, the air compressors, regenerators, intercoolers and accessories. Also, the way in which the entire unit operates and the way in which it is controlled.

Reheat Turbine and Its Control

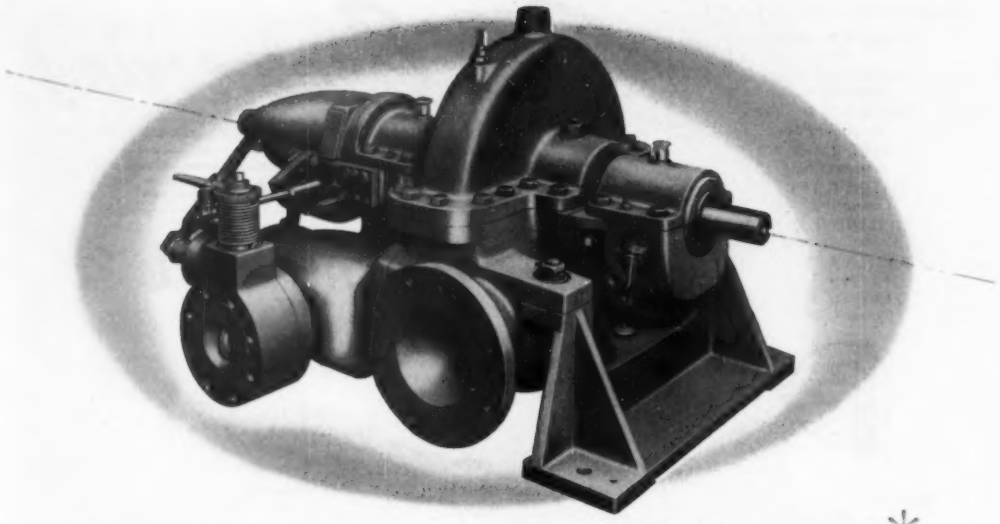
Starting with the first reheat turbine at Edgar Station in Boston, 1925, many such units were installed in the twenties, raising temperatures to 900 and then 950 F. Development in metallurgy after World War II made possible steam temperatures up to 1050 F, and there is a resurgence of interest in reheat on top of these high steam temperatures. In response to many requests we publish this comprehensive article which gets right down to details of construction, operation and control of reheat turbines.

The Practical Engineer Section

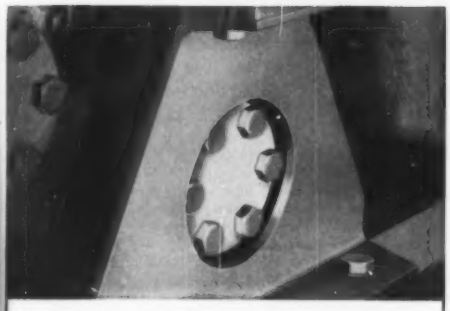
This month it contains an exceptionally interesting article by Paul Ziemke, dealing with the rehabilitation of electrical systems which have deteriorated by virtue of what in certain engineering circles is politely known as "deferred maintenance." Actually, of course, this means that the operators have let the plant go to ruin because of improper care. The war was an excellent excuse for this condition and the term "deferred maintenance" came into wide use. Regardless of the cause, Paul Ziemke tells in detail how to go about improving such systems. He shows the "rat's nest" type of wiring found in many plants—has pictures of them — and tells you what you can do about them. This is a much needed article written by a man who has been through the mill.

The article on the Vortex tube is the first account of the *practical* construction and operation of this interesting scientific curiosity. The vortex tube is a gadget run by compressed air which delivers both hot and cold air at the same time. The device is fundamentally very simple and many practical men will be interested in this article. So far there have been few practical applications of this device but as more becomes known about it, uses will undoubtedly be found.

A look at the Engelman fan mail in "Letters to the Editors" will show why we have another of his series on Basic Power Plant Figuring.



Alignment that *STAYS TRUE** when the heat's on!



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* The Type E method of support allows three-way freedom of expansion and contraction without disturbing the alignment of the rotor shaft. The governor end is mounted on a strong but flexible channel beam to permit axial expansion. At the shaft-coupling end, a unique keyed support connects to the turbine near the shaft centerline to permit lateral expansion; and a vertical kingpin transmits thrust from the expanding steam pipes directly to the foundation and not to the turbine. The casing is free to move vertically with expansion or contraction.

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There are other cost saving advantages, too. Dual protection against overspeed, weatherproof bearing seals, corrosion-resisting gland zones, floating movement of governing and trip linkage, and parts interchangeability between wheel sizes are just a few.

For the full story ask your nearby Westinghouse Steam Specialist for the Type E Turbine Book B-3896, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-50520

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TYPE E Turbines

ENGINEERS' PREVIEW

SOMETHING NEW under the American sun—the atomic energy program. Unique because production facilities wholly owned by government and almost wholly operated by industry and educational institutions. Reasons for this and details of way in which it is organized given in interesting address by Commissioner T. Keith Glennan, U. S. Atomic Energy Commission, at annual Alumni Banquet of Stevens Institute of Technology in New York City.

★ ★ ★

FACTORY STACKS 300 to 400 or more feet high might help prevent smog around factory areas, says Dr. Morton L. Barad, GE meteorologist. He is connected with Hanford Works in Washington, operated by GE for AEC. Part of Hanford's equipment is a tower 410 feet high, equipped to measure temperature, wind direction and wind speed at different levels. Data from this tower indicate that just before fog formation, temperature near ground increases with elevation. Few hours later, after fog has formed, conditions reverse. Temperature drops slightly in approximately first 100 ft, remains constant for next 200, while at top of tower for about 100 ft, temperatures increase again. If stack gases are discharged at heights of less than a few hundred feet, they will tend to settle toward ground, say Dr. Barad. Thus with stacks high enough to get emitted gases to height where temperature is increasing, smog would not settle.

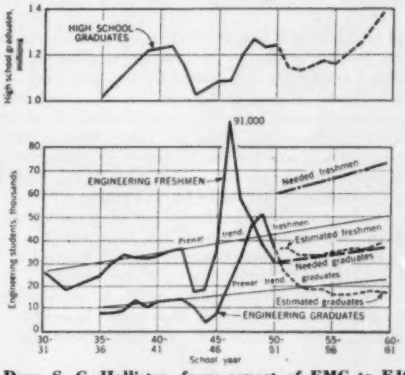
★ ★ ★

ANOTHER BEACHHEAD in battle against corrosion—methods similar to television scanning for detection, study, recording and analysis of corrosion phenomena. Developed at Armour Research Foundation of IIT, under sponsorship of NACA. Corrosion, of which rust is example, caused by thousands of local cells—microscopic flashlight batteries. In new method, laboratory sample showing corrosion is metal cylinder. Cylinder dipped in corrosive solution such as sea water, rotated several hundred times a minute, scanned with stationary probe electrode. This picks up minute electrical currents caused by corrosion, which are amplified and viewed on oscilloscope. New technique useful for study of cathodic protection, corrosion inhibitors and like. Method recently explained by Dr. Howard T. Francis, supervisor of electro-chemistry at Foundation.

★ ★ ★

ARE YOU in what is called a small business? Interested in selling, by negotiation, any of your products to foreign countries through Economic Cooperation Administration? If so, get your name on mailing list to receive urgent circulars sent out by Economic Cooperation Administration, Office of Small Business, 815 Connecticut Avenue, N.W., Washington 25, D. C., Attention: Godfrey Huber, Chief, Export Counseling Section, or Emergency Procurement Service, General Services Administration, 7th and D Sts., S.W., Washington 25, D. C. Latest circular asks for offers for immediate delivery on such items as: medical books, heavy duty mine rubber water hose, bulldozers, 46,500 gal xylene, 18 kw Diesel generators, portable self-priming centrifugal pumps with fittings, 15,000 bottles tetrachlorethylene capsules. Various combinations of these items being procured for Thailand, Turkey, Indo-China and Far East Inventory.

THE ENGINEER SHORTAGE that has suddenly developed is resulting in some radically new policies in industry. From the many statements by engineering educators and prominent engineers that have appeared in newspapers and magazines over the past month or two, everybody by this time should be aware of the situation and its importance. Last spring a widely circulated report stated that there would be an overabundance of engineering graduates in June, but developments since that time have completely reversed this. Present analyses indicate that for the next two or three years, unless something effective is done about it, there will be a shortage of engineering graduates. The colleges cannot meet the complete demands of industry at present and may fall even further behind in the future, according to Raymond D. Meade, placement director of Illinois Institute of Technology. This has brought about some unusual trends, he states in a recent issue of *The Technometer*. Ten of these are:



By Dean S. C. Hollister, from report of EMC to EJC via *Civil Engineering*.

1. More companies are interviewing prospective graduates in the colleges than ever before.
2. Salary levels for beginning engineers have increased at least 10 per cent in the last four months.
3. No graduate is beginning at less than $275 a month, and last week a company offered $500 a month for a qualified electronic engineer with a bachelor's degree. The average is $290 to $310.
4. Industry is seeking women engineers for the first time.
5. Any engineering graduate can begin work the day after graduation.
6. Engineers in sales work and service operations in industry already are being channeled into strictly engineering functions.
7. On-the-spot hiring is taking place for the first time.
8. Research managers and heads of engineering departments are accompanying personnel men who normally interview, evaluate, and refer applications.
9. Companies are willing to accept men who are eligible for the draft if they have not received their first notice.
10. Training programs have been curtailed and eliminated except in the largest companies, and graduates are being placed immediately in engineering work.

Under these conditions your Engineers' Preview Editor feels that the entire engineering profession ought to give careful attention to the procedures advocated by the Engineering Manpower Commission, as outlined in *Engineer's Preview*, January 1951, page 7.

NEW TUNGSTEN ELECTRODE to reduce inert-arc welding costs—announced by GE's Welding Divisions at Fitchburg. Major applications for inert-arc welding with d-c, straight polarity, using either argon or helium gas. This type usually used to weld mild steel, stainless steel, copper and alloys. New electrodes produce stable arc over wider range of current and resist contamination by weld metal, giving over ten times normal life. Standard tungsten electrode sputters off into work on arc starting and in minute quantities when welding, so tungsten is slowly consumed. New tungsten, called Hi-Thoria, runs cooler, remains square and intact, consumption reduced. Arc tends to stay under electrode, will not wander or climb up at low currents. Touch starting with currents as low as 5 amps. New electrode manufactured in 3- to 24-in. lengths and from 0.040 to ¼ in. diameter. Hi-Thoria not recommended as standard tungsten replacement for reverse polarity d-c, a-c welding, or atomic-hydrogen welding.

★ ★ ★

UNTIL FURTHER NOTICE, General Electric does not intend to enforce its patents on weather modification by artificial production of snow and rain. Two patents recently issued to GE on use of silver iodide for various purposes, including precipitation of moisture in natural atmospheric clouds. These are result of extensive work done by Dr. Vincent J. Schaefer and Dr. Bernard Vonnegut, GE scientists working with Dr. Irving Langmuir of GE Research Laboratory. Following their development of methods for dispensing silver iodide in extremely fine particles into sky to cause precipitation, and other discoveries, GE's weather research activities have been placed under Project Cirrus, joint weather research program of U. S. Army Signal Corps and Office of Naval Research. Scientists are consultants, field operations are performed by two services.

★ ★ ★

CENTENNIAL OF ENGINEERING 1952, Inc.—to be international convocation to celebrate one hundred years of engineering as organized profession in U. S. Eleven national technical societies and one from Canada have already taken formal action to participate. Invitations will also be extended by President Lenox R. Lohr to 60 additional technical societies in this country and to many other international or national societies in other countries. They will be invited to hold annual meetings in Chicago during convocation from September 3 to 13, 1952, or at least send representatives to convocation. Important part of celebration will be exposition during July, August and September 1952. Will tell story of engineering in industry to general public. Will be held at Chicago Museum of Science and Industry and include great human interest pageant about America to demonstrate essential role of engineer and his industrial machine in that growth. Permanent engineering exhibit to be built, open to visitors for 5 years or more. Museum is ideal setting, for it already contains displays by foremost companies in U. S.

★ ★ ★

WILDCATTERS atop 6880 ft mountain in California searching for oil. Equipment brought in on 8½-mile road costing $80,000. Water for operation pumped from well drilled 3000 ft down the mountain. Winter storms often close roads so sleeping and cooking facilities installed at rig.

COMPLETELY NEW CITY of 150,000 inhabitants to be designed to replace over-crowded Lahore as Punjab's capital in India. Charles Le Corbusier will design it. He just completed plans for modernization of Bogota, Colombia. New capital will be in sheltered green valley, high above sea, near summer resort of Simla.

★ ★ ★

WORRIED about restriction of cobalt? Well, worry a little less, for the United States is developing its own cobalt sources. By end of 1952, the U. S. will have 4,250,000 lb of cobalt annually from domestic and Canadian ores, says *Mining Engineering*. New sources of cobalt are ore bodies near Salmon, Idaho, being developed by Howe Sound Co.; the Fredericktown, Mo., ore bodies of National Lead Co. being developed by subsidiary St. Louis Smelting & Refining Co.; and the Cobalt, Ontario, ore bodies being developed by various Canadian interests. New process to recover cobalt from complex concentrates has been developed. Cobalt's largest use is for permanent magnets, especially Alnico. Also important in tool steels; also for high temperature alloys for strength at 1600 F or more; also to provide blue color in ceramic industry and so on. At present most of cobalt consumed in U. S. comes from Belgian Congo, but by end of 1952 U. S. position should be as follows:

Belgian Congo	7,500,000 lb annually
French Morocco	1,000,000 lb annually
Idaho	3,000,000 lb annually
Missouri	500,000 lb annually
Cobalt, Ont.	750,000 lb annually
Total	12,750,000 lb annually

★ ★ ★

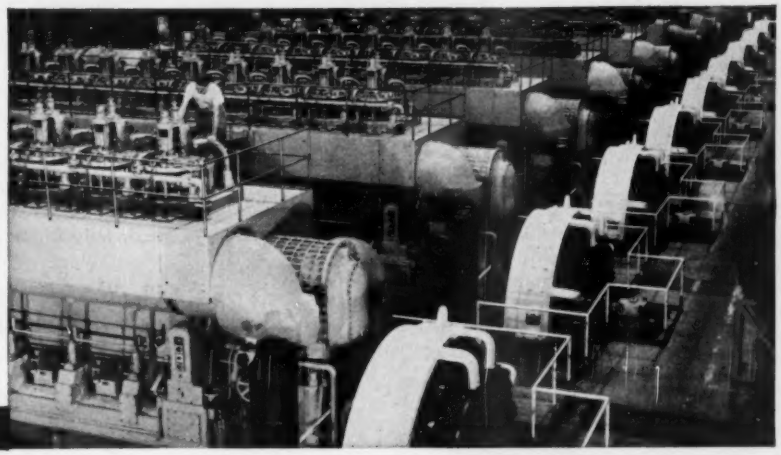
GOT PROBLEMS in lubrication of refrigeration compressors? Then better read article, Industrial Refrigeration Compressor Lubrication, in *Lubrication*, January 1951, published by The Texas Co. This shows details of both reciprocating and centrifugal compressors and their lubricating systems, discusses lubricating oil performance, pressure and temperature relations, refrigeration oil characteristics for various types and gives good refrigeration compressor service chart.

★ ★ ★

WORKING PARTY of representatives of technical and engineering societies and the business press has reported to Atomic Energy Commission that "the classification of information by the AEC has, in our opinion, been found to be satisfactory." . . . "in no case have we uncovered any 'huge amount' of secret information of value to industry, although some specific cases of valuable information are noted in our reports." Referring to latter, AEC reports work is proceeding to consider such information for declassification and publication. However, no item will be declassified if it might be of value to potential enemies. Members of working party were E. E. Thum, (chairman), editor, *Metal Progress*, representative ASM; Keith Henney, consulting editor, *Nucleonics* and *Electronics*, representative of IRE; S. A. Tucker, editorial director, ASME; and F. J. Van Antwerpen, editor, *Chemical Engineering Progress*, representative of AICE.

To follow up recommendations of working party, Commission recently appointed N. H. Jacobson, formerly in charge of technical press relations for the Allis-Chalmers Mfg. Co., to be Technological Information Officer on the staff of AEC's Technical Information Service.

GIANT ALUMINUM PLANT GAS DIESELS 100% TEXACO-LUBRICATED



Engines in Reynolds Metals Company Jones Mills Arkansas Aluminum Reduction Plant—one of the world's largest internal combustion plants — include 18 Nordberg Gas Diesels, 9 of which are shown in the illustration. Each of these 9-cylinder, 2-cycle, gas-burning 3,600 h.p. Gas Diesel giants required 16 flat cars for transportation from factory to plant site. *Texaco Ursa Oils* are used exclusively.

Reynolds Metals Company Diesels have used TEXACO URSA OILS exclusively since installation in 1943

For eight years *Texaco Ursa Oils* have given the Gas Diesels in this mammoth installation trouble-free, economical operation. Eighteen giant Gas Diesel engines have delivered full power, with minimum maintenance expense—thanks to *Texaco Ursa Oils*.

Regardless of engine size, efficiency goes up and fuel consumption goes down when you lubricate with *Texaco Ursa Oils*. These fine lubricants resist oxidation, combat carbon and sludge formation, keep ports open and rings free . . . assuring better compression and combustion. *Texaco Ursa Oils* stand up under heat or pressure. Engine parts last longer . . . you save on maintenance costs.

Texaco Ursa Oils are approved by leading engine manufacturers. When you change to Texaco, you'll join the large group of satisfied Texaco users, as witness the fact:

More stationary Diesel h.p. in the U. S. is lubricated with Texaco Ursa Oils than with any other brand.

Let a Texaco Lubrication Engineer help you to get better engine performance with the *Texaco Ursa Oil* best suited for your operation. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

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BOILER WATER LEVEL *Shines*

It's light! It's bright! It's right! You see instantly the accurate boiler water level in your Yarway Flat Glass Gage because *the meniscus at water level stands out like a brilliant star . . .* thanks to the new Yarway Type "M" Illuminator.

The Type "M" Illuminator is specially-designed to give maximum brilliance to Yarway flat glass inserts, and to spot the water level over its entire traverse. The superior penetration of its blue-white light cuts through extraneous light, dust particles in the air, and deposits on the gage glasses. Effective over longer distances.

New or already-installed Yarway Flat Glass Gages may be equipped with the Illuminator. Yarway Illuminators may be installed in pairs on four-glass gages.

Get in touch with your nearest Yarway office for further details on this latest Flat Glass Gage development, or write direct to . . .

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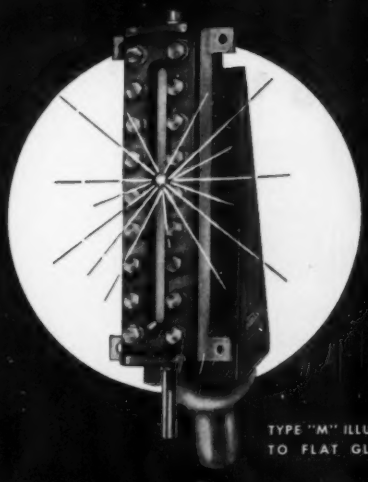
A COMPLETE YARWAY WATER LEVEL SYSTEM

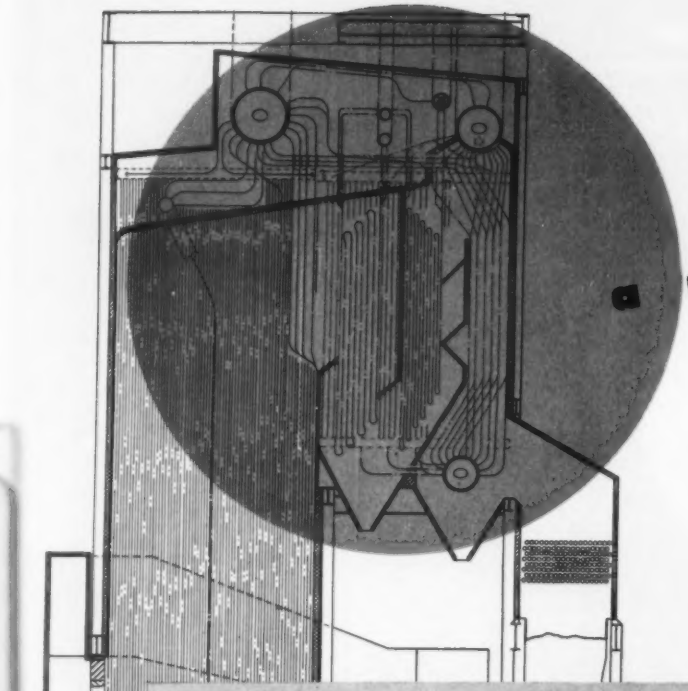
YARWAY STEAM

like a Star



TYPE "M" ILLUMINATOR ATTACHED
TO FLAT GLASS GAGE INSERT

PLANT EQUIPMENT



a utility

THE answer to many problems facing steam-electric plants requiring an abundant steam supply at high pressures and temperatures for power and process is being provided by Foster Wheeler Dual Circulation Steam Generators. The advantages of Dual Circulation are already being proved in refinery application where these problems are further complicated by high make-up and high solids concentrations in the make-up and boiler feedwater.

In recognition of the advantages of the Dual Circulation Steam Generator in the public utility field where make-up normally is relatively low, a midwestern utility recently ordered the three-drum unit shown above. This unit is designed for a capacity of 425,000 lb per hr and will deliver steam at a pressure of 1350 psi and a temperature of 955 F. The low carryover, previously unattainable, will reduce boiler and turbo-generator outages with consequent savings in maintenance costs and gains in operating revenue. The advantages of the Dual Circulation Steam Generator over standard units are illustrated at the right.

● *Write for a Copy of Bulletin B-50-11*

FOSTER WHEELER CORPORATION 165 BROADWAY NEW YORK 6.

specifies... DUAL CIRCULATION

REDUCED CARRYOVER OF

a. Silica

b. Total Dissolved Solids

LOW CONCENTRATION IN HIGH DUTY FURNACE SECTION RESULTING IN

a. Minimum Tube Damage

b. Reduced Maintenance and Outage Time

IMPORTANT SUPPLEMENTARY ADVANTAGES IN CERTAIN APPLICATIONS

a. Reduced Blowdown With Resulting Reduction In Heat Loss and Size of Heat Recovery Equipment

b. Reduced Cost of Chemicals and Equipment For Water Treatment

NEW YORK **FOSTER WHEELER**

WHY SO MANY LURES?

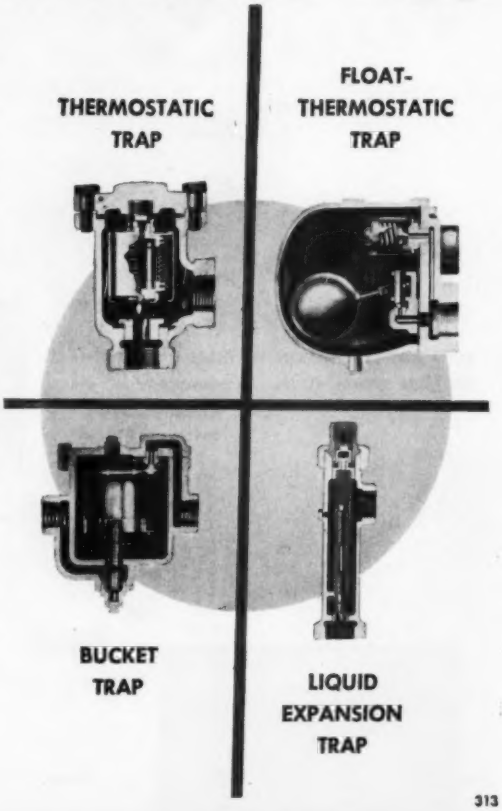
A practical idea for users of STEAM TRAPS

Many readers of this publication can remember when there was only one kind of steam trap and when one trap to a room or a building was enough. As long as the trap "tilted," everybody was happy.

The science of steam trapping has come a long way since then but we still have with us the engineer who tries to "standardize" on one type of trap for the whole plant and the steam man who doesn't realize that the cost of Sarco traps is so reasonable today that it pays to put one on each coil.

One thing is certain. You will need several types of steam traps to lure the utmost out of your fuel and your production equipment. Sarco makes five distinct types of steam traps and is in a position to recommend the right type for each job.

And you can't tell by the cost. An inexpensive type of trap may be the best and the most expensive trap the worst type you could use on any particular job. You can get the right trap the first time for each job by asking the Sarco Specialist near you or writing for our Selection Chart No. 1600.



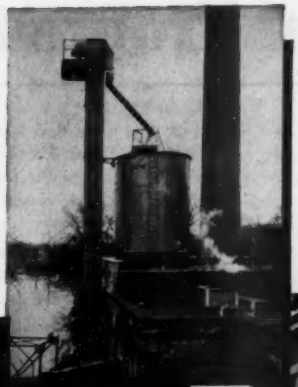
313

SARCO SAVES STEAM

SARCO COMPANY, INC.
Represented in Principal Cities
Empire State Building, New York 1, N. Y.
SARCO CANADA, LTD., TORONTO 8, ONTARIO

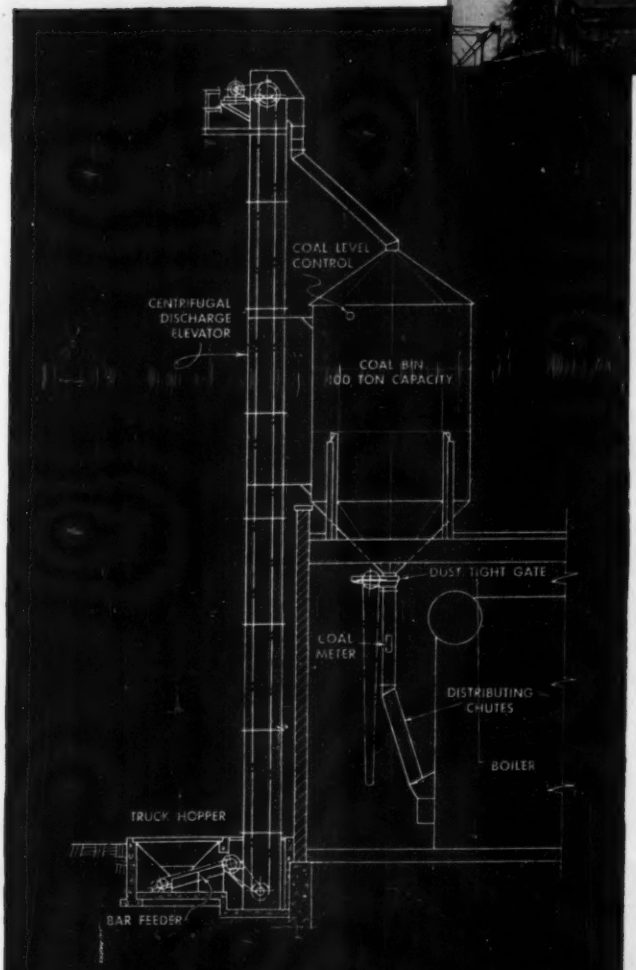
IMPROVES PRODUCT QUALITY AND OUTPUT

IN THIS CASE
tight quarters saved dollars



G-W Bucket Elevator and Steel Bin on Roof of Braendly Dye Works.

G-W Tri-furcated Distributing Chute Feeding Coal Directly to Stokers from Bin above Boiler Room.



When Braendly Dye Works, Inc., at Beacon, N.Y., modernized their steam boiler plant, a mechanical coal-handling system was required to replace the old, slow manual method. A G-W engineer was called in... recommended the elevator-storage system illustrated.

A river bank restricted ground storage space... a disadvantage that G-W ingenuity converted into economies. A live storage, steel bin was designed and mounted on roof directly over boiler room. Coal is supplied to bin by a bucket elevator and fed continuously by gravity directly to stokers. Warm boiler room air surrounds bottom cone of bin... prevents coal freezing.

Elevator boot is fed by bar type feeder which permits a truck hopper shallow enough to safeguard against flooding when river is high.

G-W took over *this* complete job ... from design through construction and erection...shouldered all responsibilities. G-W's complete engineering service is yours for the asking.

4500-A

G-W HANDLES IT...
faster • easier • cheaper

SINCE 1814

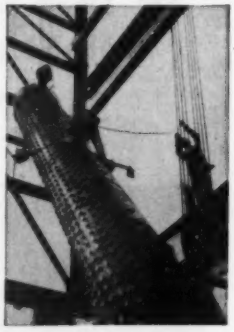
NEW YORK 17
420 LEXINGTON AVENUE

Factory:
Hudson, N. Y.

CHICAGO 6
565 W. WASHINGTON ST.

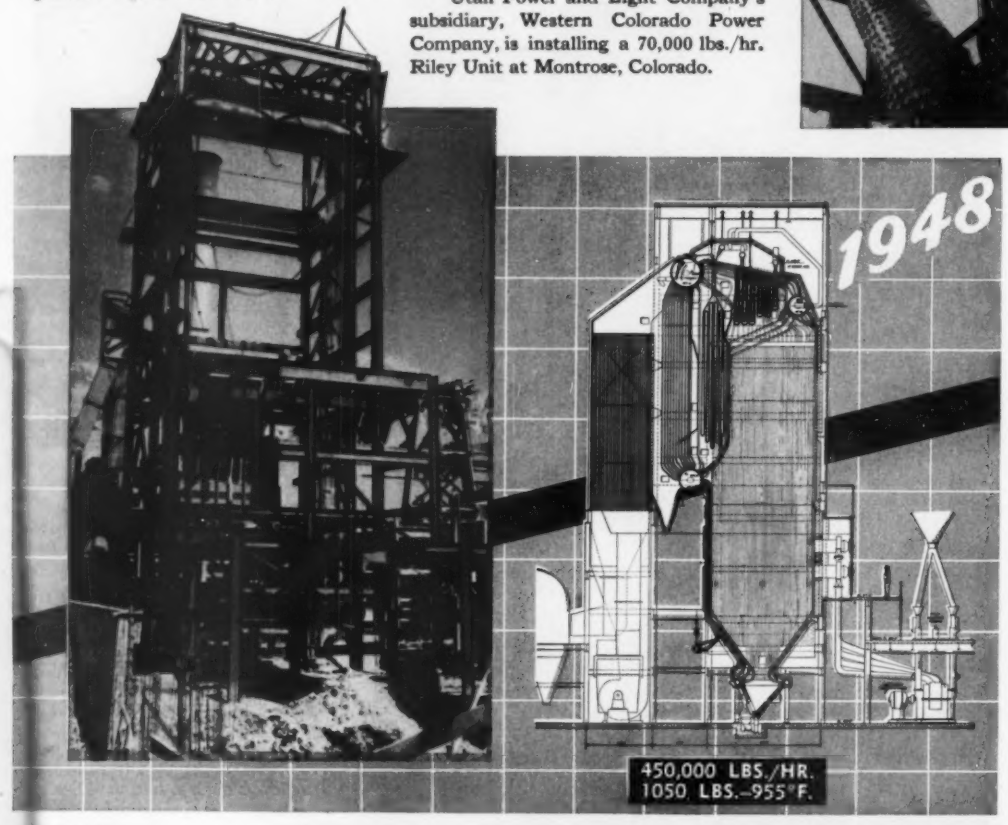
Pattern of Progress at Utah Power

Utah Power and Light Company has instituted a program tremendously increasing its power producing capacity. While their Pattern of Progress includes expansion of many facilities other than their steam power plants, it is an all Riley performance insofar as new steam generating units are concerned.



Utah Power and Light Company installed its first Riley Unit at its Orem Station in 1948—a 450,000 lbs./hr. Riley Unit. Utah Power and Light Company is now installing a 620,000 lbs./hr. 1500 psig 955°F. Riley Unit at its New Jordan Station, and has ordered a 575,000 lbs./hr. 1700 psig 1000°F. reheat Riley Unit to be placed in operation in 1952.

Utah Power and Light Company's subsidiary, Western Colorado Power Company, is installing a 70,000 lbs./hr. Riley Unit at Montrose, Colorado.



TRADE MARK Rx REGISTERED

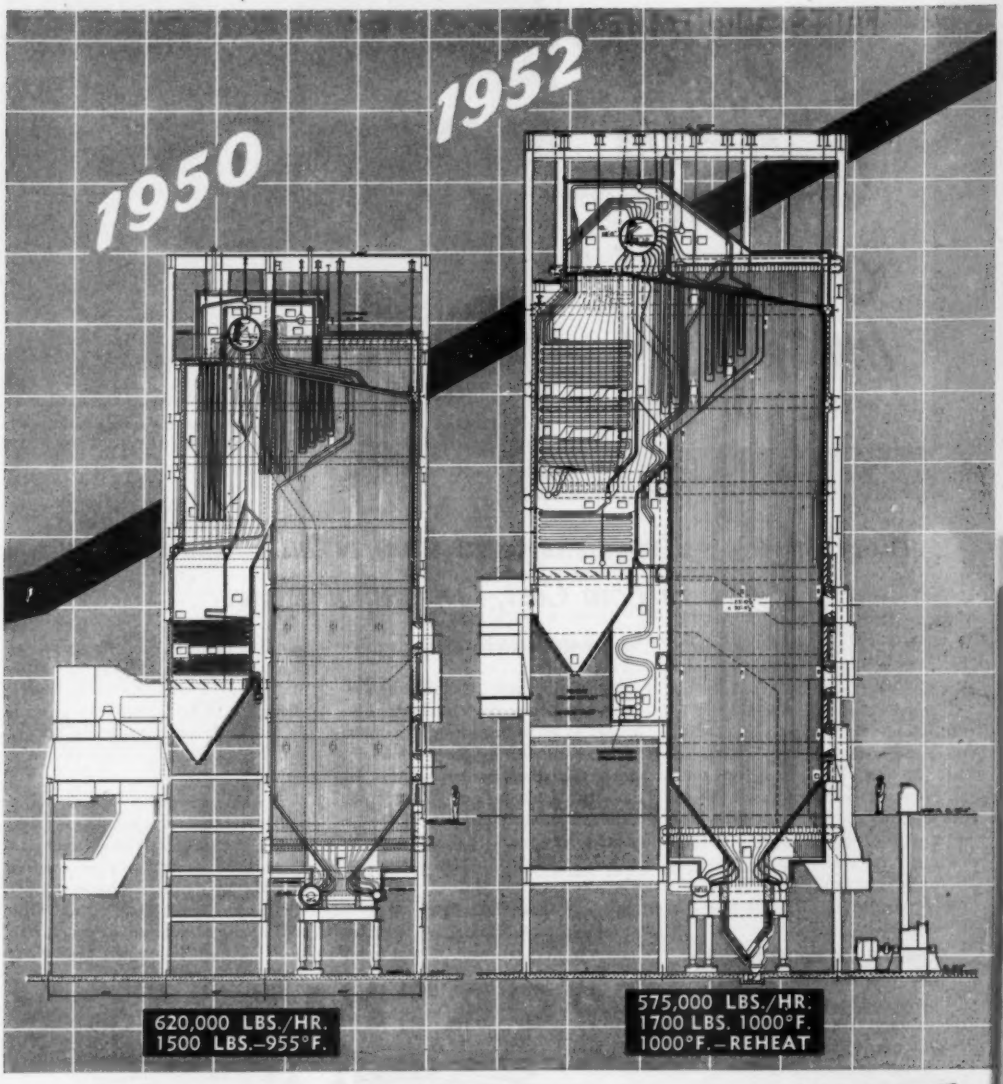
RILEY

STOKER CORPORATION, WORCESTER, MASS.

Boston · New York · Philadelphia · Washington · Buffalo · Pittsburgh · Cleveland · Detroit · Chicago
Cincinnati · Atlanta · New Orleans · Memphis · St. Louis · Kansas City · St. Paul · Tulsa · Houston
Denver · Salt Lake City · Los Angeles · Portland · Seattle

BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • FLUE GAS SCRUBBERS

& Light - an all RILEY Performance



A survey of your Power Plant by a consulting engineer will possibly show ways of making surprisingly large savings

COMPLETE STEAM GENERATING UNITS

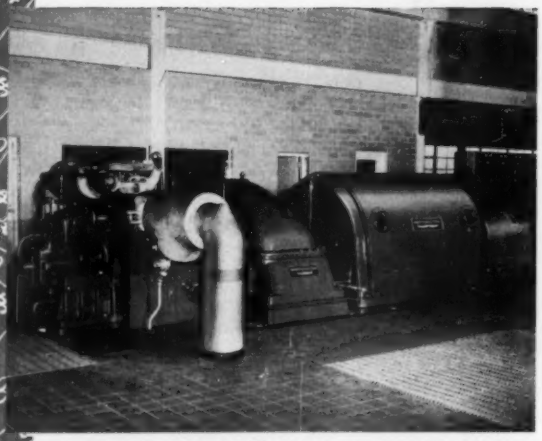
. . . it will pay you to visit modern Riley Installations before purchasing Boiler or Fuel Burning Equipment

ECONOMIZERS • WATER-COOLED FURNACES • STEEL-CLAD • AIR HEATERS

FACTS ABOUT THE

Most Profitable Turbine Generator Investment

YOU CAN MAKE...



One of two Worthington 4000 kw turbine generator sets installed in a mid-western municipal power plant, operating on 600 #G and 750 F.T.T. Steam exhausting to 28" Hg vacuum.

Worthington's Experience and Undivided Responsibility Assure Low Cost, Dependable Power

Builders of steam turbines for over 30 years, Worthington's Steam Turbine Division is backed by the experience and resources of the entire Worthington organization — recognized leaders in the power plant field for more than a century. In view of today's increased turbine pressures and temperatures — and the resulting needs for new and special materials — this vast, combined source of technical knowledge has proved of tremendous practical value in developing turbine design, construction and performance.

Generators Are Worthington's, Too

The generators used with Worthington Turbines are built by a Worthington subsidiary that has specialized in this field for over 45 years. This means that Worthington, as manufacturers of *complete* turbine generator units, assumes *undivided responsibility* for the coordinated design, assembly and performance of these units.

Before shipment, Worthington Turbines and Generators are assembled together *as units* for testing and adjustment — eliminating the necessity for doing this after installation. Also, for installation and service, Worthington turbine specialists and regular Worthington service men are always available from our District Offices throughout the country.

Check These Over!

Adding up, Worthington's matchless power plant experience . . . huge manufacturing facilities . . . long specialization in both turbine and generator manufacture . . . undivided unit responsibility . . . and skilled technical service . . . are the best assurance you can get anywhere of efficient, economical steam turbine power.

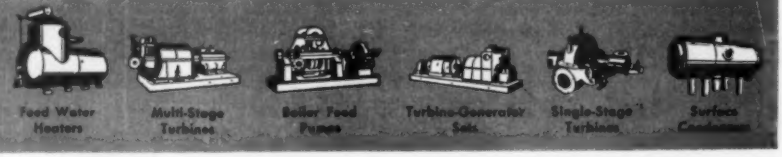
Worthington makes turbines in a wide range of sizes and types, each one designed to make steam do more work. For details proving *there's more worth in Worthington*, contact your nearest Worthington representative. Or write to *Worthington Pump and Machinery Corp., Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

STEAM TURBINES

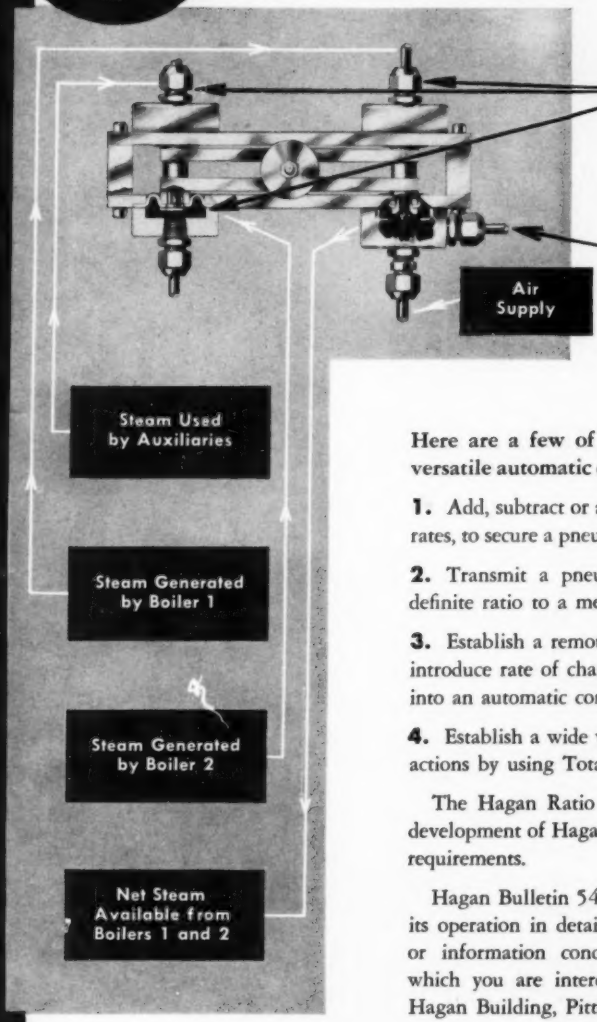
T0.2

A GREAT TEAM IN STEAM



another *FIRST* by HAGAN

HAGAN ratio totalizer


Air Supply
Steam Used by Auxiliaries
Steam Generated by Boiler 1
Steam Generated by Boiler 2
Net Steam Available from Boilers 1 and 2

up to 3 input signals combined accurately to give 1 pneumatic output signal

Here are a few of the things you can do with this versatile automatic control mechanism.

1. Add, subtract or average pneumatic indications of flow rates, to secure a pneumatic indication of the totalized flow.

2. Transmit a pneumatic output signal which is in a definite ratio to a measured static pressure.

3. Establish a remote pneumatic set point adjustment or introduce rate of change or automatic reset characteristics into an automatic control system.

4. Establish a wide variety of selector or limiting control actions by using Totalizer units singly or in multiple.

The Hagan Ratio Totalizer is typical of the constant development of Hagan Control Systems to meet advancing requirements.

Hagan Bulletin 5450 describes the Ratio Totalizer and its operation in detail. To secure a copy of this bulletin, or information concerning any specific application in which you are interested, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

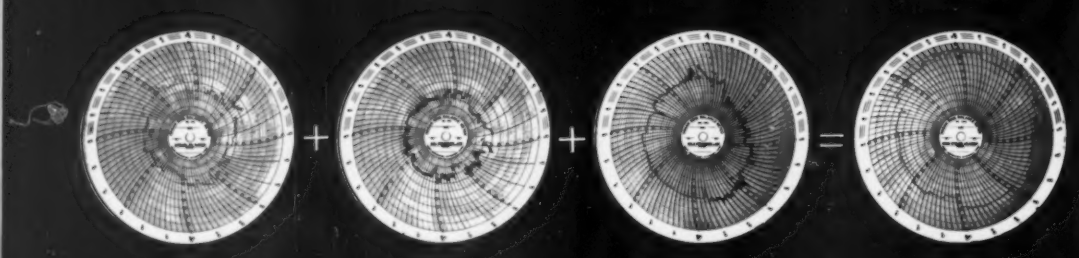
HAGAN CONTROLS

HAGAN CORPORATION

RING BALANCE HAGAN Ring Balance

HAGAN BUILDING, PITTSBURGH 30, PA.

combustion control systems . . . ring balance flow and pressure instruments



Dependable
Steam Records
with
HAGAN
Ring Balance Meters

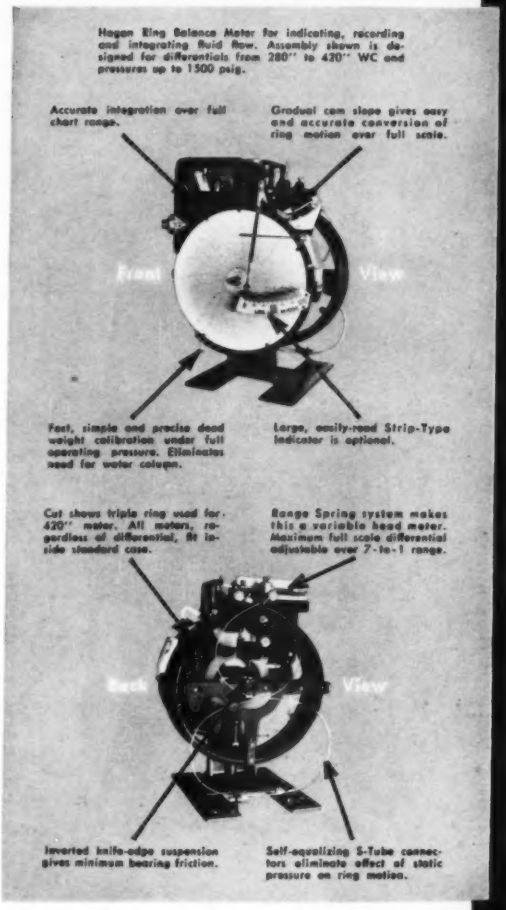
The steady increase in steam costs makes it more important than ever to have accurate records of steam distribution, so that costs can be allocated properly.

With Hagan Ring Balance Meters, your steam production and distribution records are accurate, and distribution costs can be made on the correct basis. Your records will be reliable over the entire chart range, for Hagan Ring Balance Meters instantly follow all flow changes, from 100% down to zero.

The Integrator totalizes flow automatically, and is accurate over the full scale.

Hagan Ring Balance Meters are available in single or dual models, with or without automatic pressure and temperature compensation, and for full scale differentials from ½" to 420" of water.

For more information about Hagan Ring Balance Meters, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.


Hagan Ring Balance Meter for indicating, recording and integrating fluid flow. Assembly shown is designed for differentials from 280" to 420" WC and pressures up to 1500 psig.
Accurate integration over full chart range.
Gradual cam slope gives easy and accurate conversion of ring motion over full scale.
Front View
Fast, simple and precise dead weight calibration under full operating pressure. Eliminates need for water column.
Large, easily-read Strip-Type indicator is optional.
Cut shows triple ring used for 420" meter. All meters, regardless of differential, fit inside standard case.
Range Spring system makes this a variable head meter. Maximum full scale differential adjustable over 7-to-1 range.
Back View
Inverted knife-edge suspension gives minimum bearing friction.
Self-equalizing S-Tube connectors eliminate effect of static pressure on ring motion.

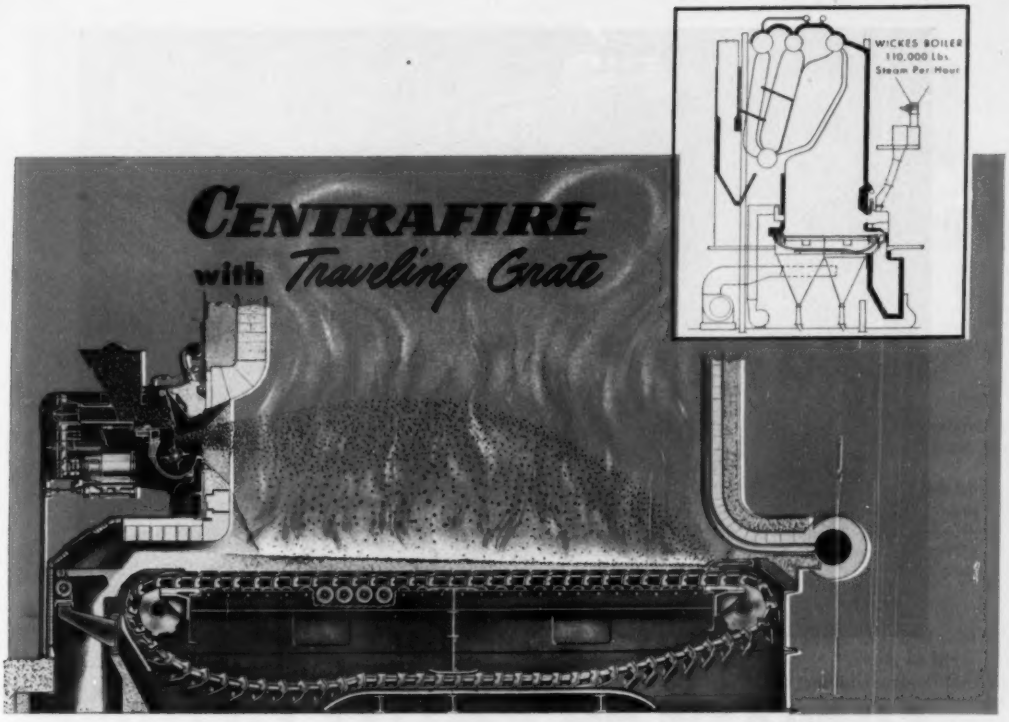
HAGAN

HAGAN
CORPORATION

RING BALANCE HAGAN Ring Balance

HAGAN BUILDING, PITTSBURGH 30, PA.

combustion control systems . . . ring balance flow and pressure instruments



. . . . brings Extra Engineering Refinements to Spreader-Type Firing

The outstanding performance of the Centrafire® with Traveling Grate stems from features that are built in —not added as accessories.

A positive, metered flow of coal, wet or dry, is fed continuously by an air-cooled overthrow rotor into the combustion area. Proper distribution is effected automatically by cyclic control of the rotor speed.

All moving elements are hydraulically operated by one turbine—or motor-driven oil pump. This assures infinite flexibility through the complete range of operation—synchronizes coal feed and grate speed.

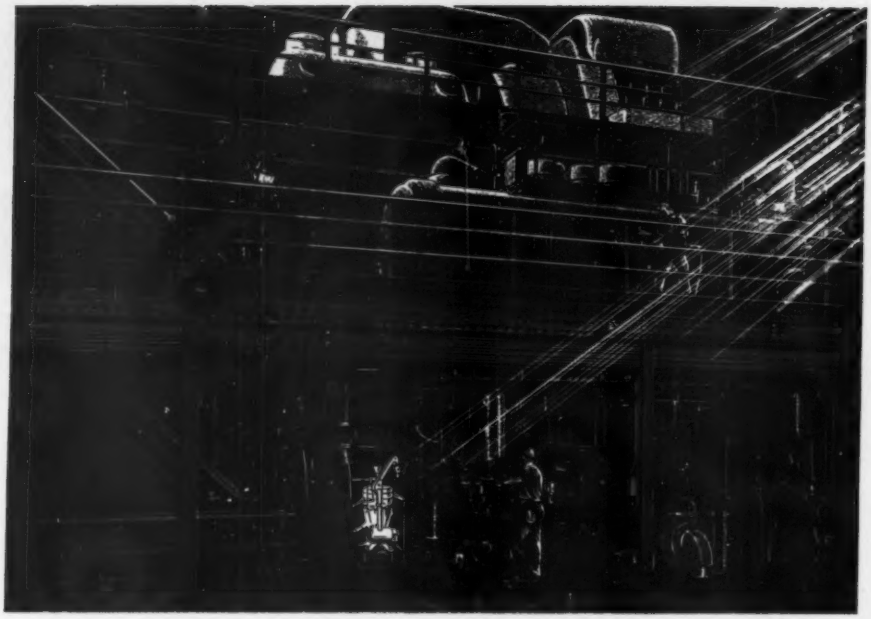
Grates are plate-type, laboratory tested under conditions far more severe than those of actual service conditions. Roller-supported grate chains reduce friction and power requirements.

Fuel distribution adjusted automatically to air flow through front and rear grate sections results in intimate mixing of fuel and air for thorough combustion.

The Centrafire's range extends upward of 300,000 lbs. of steam per hour. Its adaptability to deep, narrow furnaces permits use of the most economical boilers.

Ask your Westinghouse representative for complete data, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-50522

YOU CAN BE SURE.. IF IT'S
Westinghouse
STOKERS

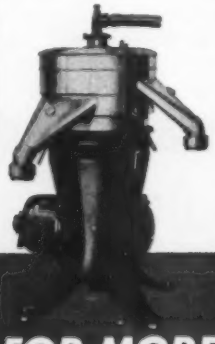


EMPHASIS ON *PROTECTION!*

A De Laval Oil Purifier keeps turbine oil as safely clean as it was the day it was delivered by the refiner. It costs only a fraction of the cost of the power units it protects, and this cost is far outweighed by even one serious shutdown due to oil becoming contaminated.

A De Laval Oil Purifier instantaneously removes from lubricating oil all water, dirt or sludge. By most effectively utilizing centrifugal force it keeps turbine oil so clean that it can be used indefinitely. As the operation is wholly mechanical, everything harmful to the oil is thrown out, but valuable oxidation inhibitors added by the refiner are retained even after thousands of hours of continuous purification.

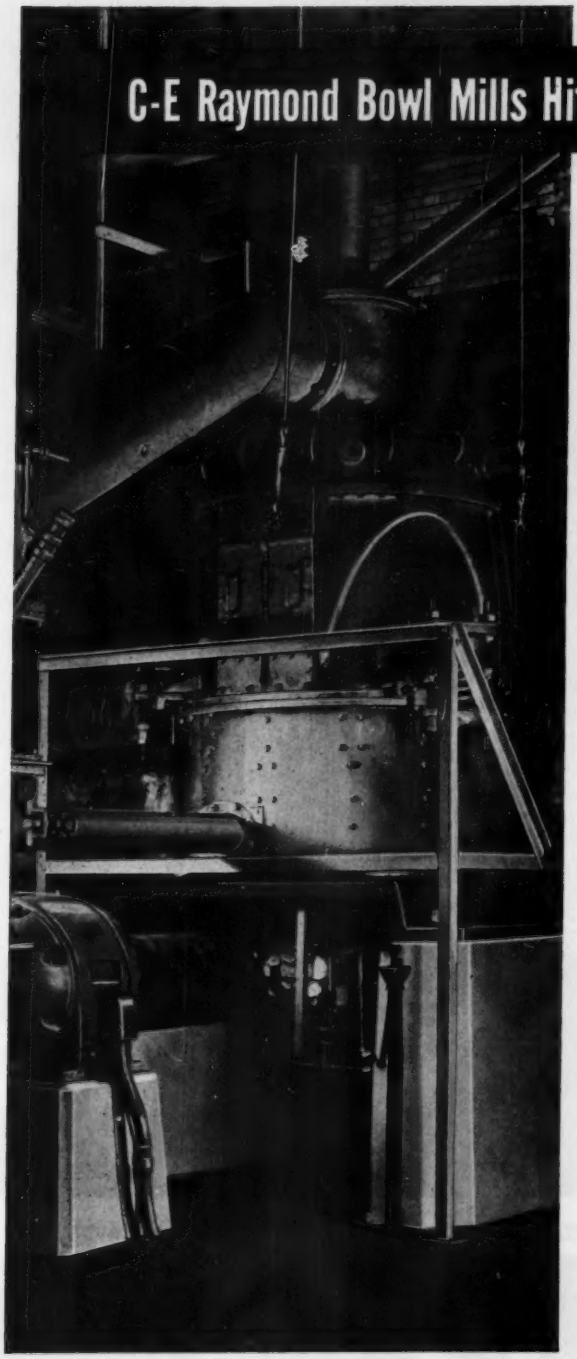
There is a wide range of sizes to accommodate the capacity requirements of plants of all sizes.



The installation pictured above is in one of the great central stations of the East. It is described in the De Laval Centrifugal Review, Volume 16, No. 1. Sent free on request. ***Write for a copy.***

THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 6 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5
THE DE LAVAL COMPANY, Limited, Peterborough, Ont.

DE LAVAL
OIL PURIFIERS
FOR MORE DEPENDABLE POWER PRODUCTION



C-E Raymond Bowl Mills Hit New High in 1950

ordered for 5,000,000 kw of new electric generating capacity

Perhaps an even more impressive indication of Bowl Mill acceptance throughout the utility industry is the fact that . . .

. . . if all Bowl Mills purchased by American utility companies from January 1 to December 31, 1950, were to operate at 70% use capacity factor for a year, they would pulverize a total of

20 million tons of coal —

that's about ¼ of the amount of coal used by all utility companies in 1949.

No one factor could possibly account for this widespread acceptance. Rather it is the fact that the Bowl Mill's record of performance in hundreds of installations has been *outstanding* in *all* these important respects . . .

- **power consumption**
- **maintenance costs**
- **control characteristics**
- **ability to maintain capacity with wet coal**
- **ability to maintain fineness through life of grinding elements**
- **quiet vibrationless operation**

Check the facts of Bowl Mill performance on *all* these counts and you will understand why utility engineers continue to accord it such widespread preference. B-457

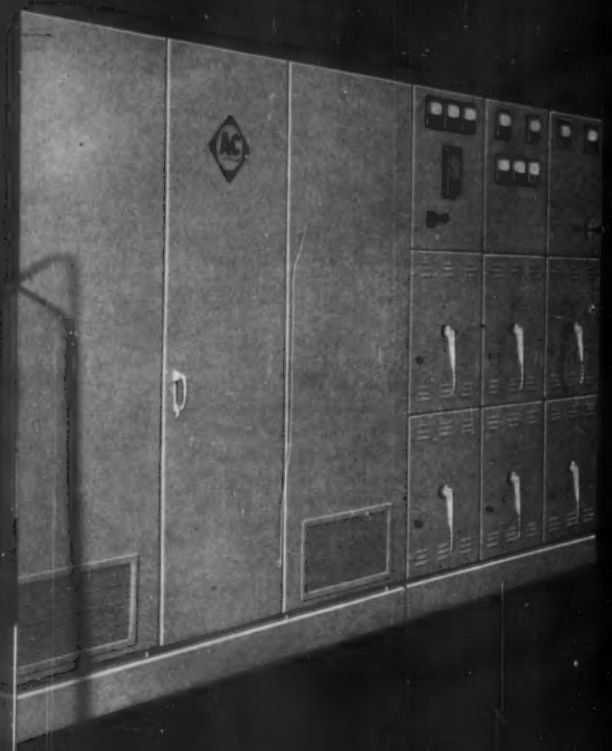
C-E

COMBUSTION ENGINEERING-SUPERHEATER, INC.

200 Madison Avenue • New York 16, N. Y.

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

ALLIS-CHALMERS
LOAD CENTER UNIT SUB-STATIONS



ALLIS-

PIONEERS IN POWER AND

480 VOLTS FOR SMALL, MEDIUM SIZED MOTORS

Eleven 1500 KVA, 6 feeder Dry Type LCS Unit Substations, properly located in the plant, supply power at 480 volts for machines requiring smaller horsepower motors. Motors up to 50 or even 200 hp are more readily available at 480 than at higher voltages.

2400 VOLTS FOR LARGER MOTORS

For the larger motors — mostly constant speed — 2400 volts was selected as most economical. Two 2500 KVA 4 feeder Indoor Dry Type MCS Unit Substations, similar in appearance to the LCS units, were used. They have field application equipment for across-the-line motor starting.

NUMBER 4
IN A SERIES
Solving Industrial Power Distribution Problems

- Paper Mill Engineers
- Consulting Engineers
- A-C Engineers

WORK TOGETHER TO CREATE

"Tailored" Distribution

A LARGE PAPER MANUFACTURER faced a major electrical problem in converting a southern war plant into a big, 300 tons a day newsprint plant. Increased load requirements were easily established . . . but determining the method of power distribution presented problems — problems of equipment and of balancing economy against reliability.

Called in early during planning, Allis-Chalmers engineers worked with consulting engineers and paper mill experts. Together they examined the problems: type of load, density, cost and availability of equipment, installation and maintenance costs. Together, they decided on a system of equipment *tailored* to the specific needs of this plant. Now installed, this system is made up of 11 Dry-Type LCS Load Center Unit Substations and two Primary Dry-Type MCS Multi-Circuit Unit Substations located throughout the plant. They are operating to the mill owner's complete satisfaction.

DO YOU HAVE A SPECIAL POWER DISTRIBUTION PROBLEM?

Your distribution problem can be solved by this same kind of cooperation . . . your experts, familiar with your plant and products — working *together* with Allis-Chalmers engineers, experts in power distribution and distribution equipment. Remember, the basic planning stage is the best time for you to call on this Allis-Chalmers service. Phone your nearby A-C representative, or write direct.

Allis-Chalmers
Milwaukee 1, Wis.

A-3116

CHALMERS

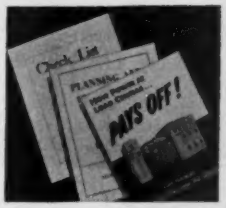
ELECTRICAL EQUIPMENT FROM GENERATION THROUGH UTILIZATION

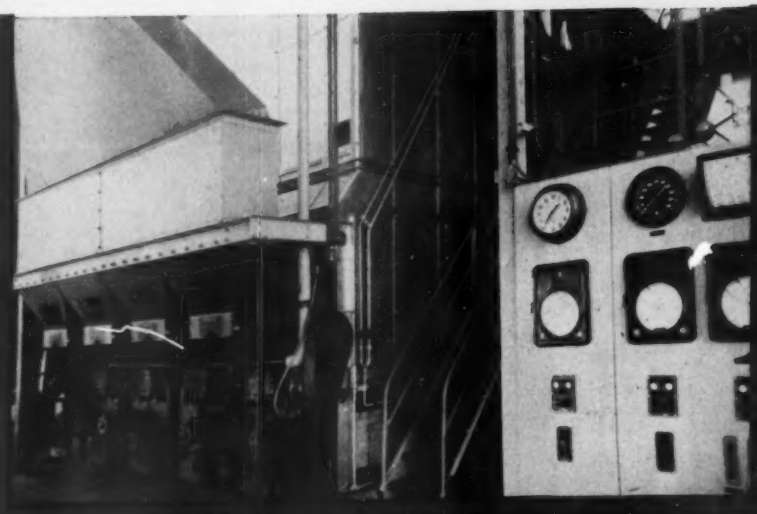
UNIFORM INSPECTION PROCEDURE

User preferred dry type transformers for 480 volt substations. Dry type transformers were also used on the recommendation of A-C engineers for 2400 volt units to eliminate liquid handling problems and permit a uniform inspection and maintenance program.

SEND FOR LITERATURE

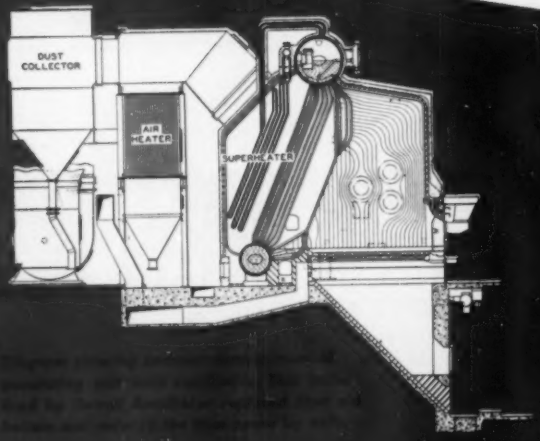
Bulletin 11B6285A, "How Power at Load Centers Pays Off!", bulletin 11B6325B, "Check List to Simplify Unit Substation Planning," bulletin 11B6895, "Planning and Engineering Guidebook for LCS Unit Substations." Use them when planning your Substation.

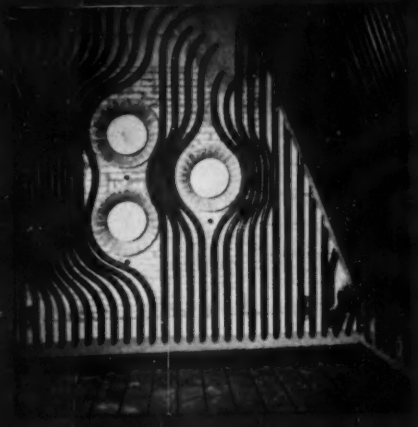


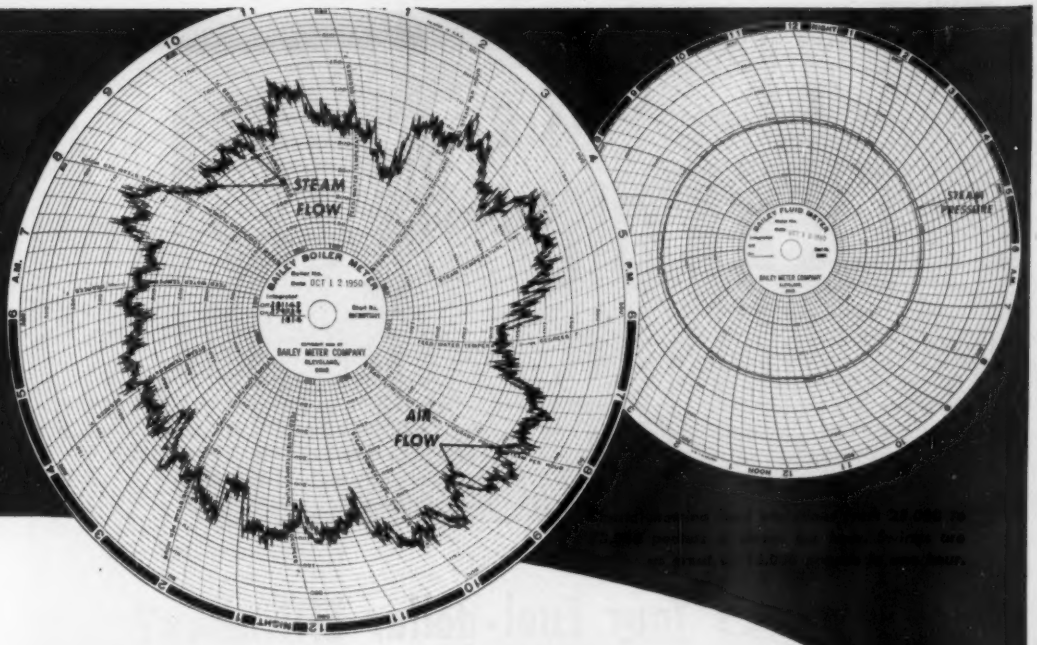


DETROIT ROTOSTOKER

...and rapidly fluctuating load with uniform pressure







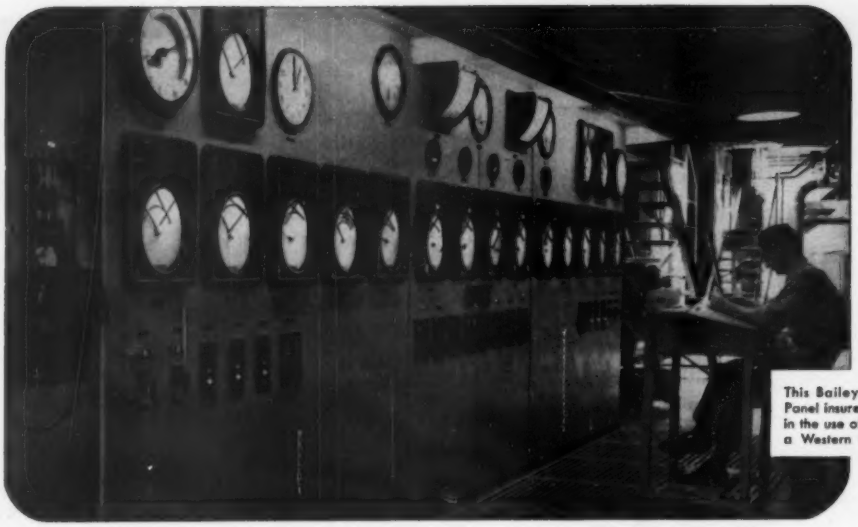
at Kerr Bleaching & Finishing Works, Inc.

CONCORD, N. C.

Detroit RotoStoker with Babcock &

40% Fuel Saving

DETROIT STOKERS



This Bailey Boiler Control Panel insures high efficiency in the use of Fuel-Dollars at a Western Chemical Plant.

What's Your Fuel-dollar Efficiency?

A dollar's worth of fuel has the *same potential* energy, no matter who's boiler it fires. But how much of the energy actually gets converted to a usable form depends on how you operate your boiler.

That's where Bailey Controls can help. And, here's why, we believe, you'll get better fuel-dollar efficiency with Bailey:

1. **Complete Range of Equipment—fully co-ordinated.** You need never worry that a Bailey Engineer's recommendation is slanted in favor of a particular type of equipment, just because he has a limited line to sell—or that Bailey will pass the buck for efficient control; we offer *complete* boiler control systems.

2. **Engineering Service—backed by experience.** No other manufacturer of instruments and controls can offer as broad an experience, based on successful installations involving all types of combustion, flow measurement and automatic control.

3. **Direct Sales-Service—conveniently located near you.** Bailey Meter Company's Sales-Service Engineers are located in more industrial centers than those of any other manufacturer of boiler control systems; you get prompt, experienced service with a minimum of travel time and expense.

•

For better fuel-dollar efficiency—for more power per fuel-dollar, less outage and safer working conditions, you owe it to yourself to investigate Bailey Controls. Ask a Bailey Engineer to arrange a visit to a nearby Bailey installation. We're proud to stand on our record: "More power to you!"

A-109-1

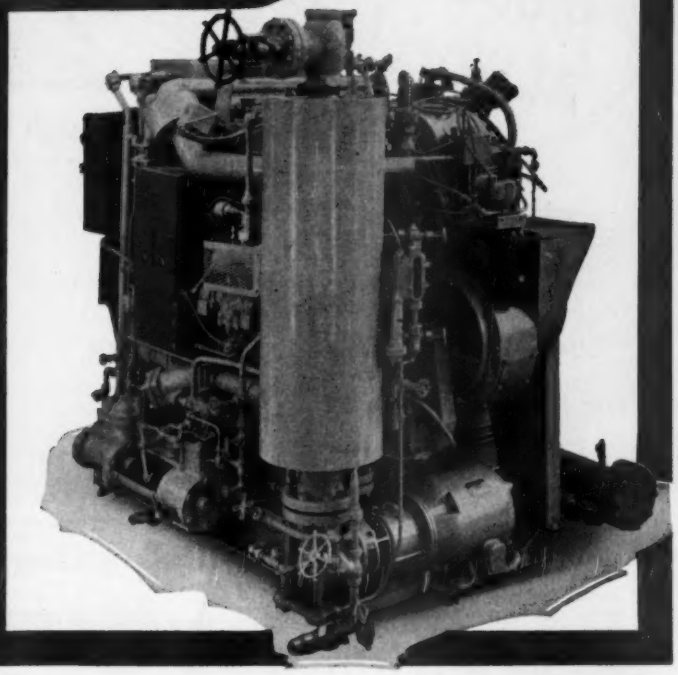
BAILEY METERS

BAILEY METER COMPANY

1040 IVANHOE ROAD
CLEVELAND 10, OHIO

Controls for Steam Plants
COMBUSTION · FEED WATER
TEMPERATURE · PRESSURE
LIQUID LEVEL · FEED PUMPS

Not a Package Boiler—but a PACKAGED STEAM PLANT



Do you need steam . . .

. . . for heating, processing or both—in unit capacities up to 6,000 pounds per hour—for pressure up to 300 psi?

. . . in remote locations involving the expense of installing and maintaining long insulated pipe lines?

. . . for intermittent requirements—a few hours each day or week?

. . . for an occasional load which may exceed the capacity of existing boilers?

. . . for a highly fluctuating load which involves sudden heavy demands?

. . . with completely automatic operation; with a minimum of attention necessary?

. . . at maximum output from minimum space?

If you do—if you have any one or a combination of these requirements—your best bet is the C-E Re-circulation Steam Generator . . . more than a package boiler . . . a complete steam plant, including all controls and auxiliaries in a fully integrated unit. Send for bulletin p-323.

B-458

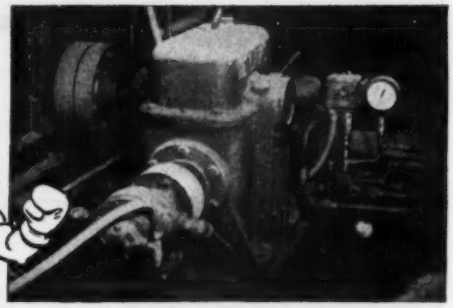
C-E

COMBUSTION ENGINEERING—SUPERHEATER, INC.

200 Madison Avenue, New York 16, N. Y.

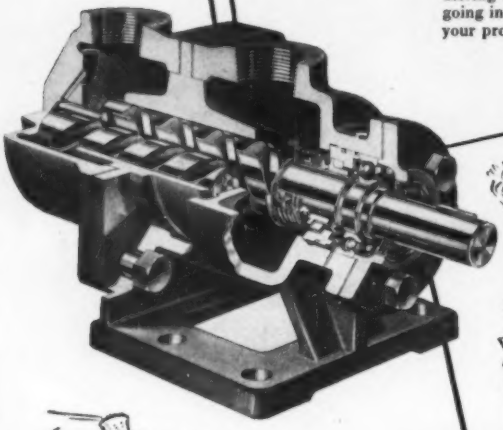
ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

De Laval products at work!



Tough service?... You bet!

0 to 800 rpm in 8/10 Second . . . 26 Times per Minute. And this De Laval speed reducer takes it and likes it. This particular unit is driving a conveyor belt that automatically feeds and measures billets going into a shear. If you are rough on reducers in your plant, tell your problems to one of our power transmission engineers.



What do you want to pump?

Molasses, Glue, Lard, Soya Oil, Film Dope, Corn Syrup, Vegetable Oil, Paste, Fuel Oil, Shortening, Resin, Varnish, Linseed Oil, Viscose Rayon, Liquid Latex . . .

We frankly don't know all the other products that an IMO can pump, but if you want a better way to transfer fluids like these from one place to another, chances are an IMO can do the job for you. The IMO is a screw-type rotary pump. Its axial flow design permits liquids to be pumped close to the axis of the rotor. This means low liquid velocity through the pump and quiet pulsation-free flow. Capacities range to 1000 gpm at 500 psi and 150 gpm at 1500 psi.

There's a new idea here!

We've simplified the already simple centrifugal pump! Our new GS pump is designed so that every working part . . . every part subject to wear, is contained in one easily replaced unit rotor assembly. Through our Service and Exchange Plan new rotor assemblies are available for immediate shipment from conveniently located stocks throughout the country.

This means good service, and if maintenance ever does become necessary, all you have to do is remove the cover and end plate bolts, lift out the old rotor and drop a new one in place. *It's that easy!* Capacities to 400 gpm — heads to 230 feet.

DE LAVAL STEAM TURBINE CO., TRENTON 2, N. J.

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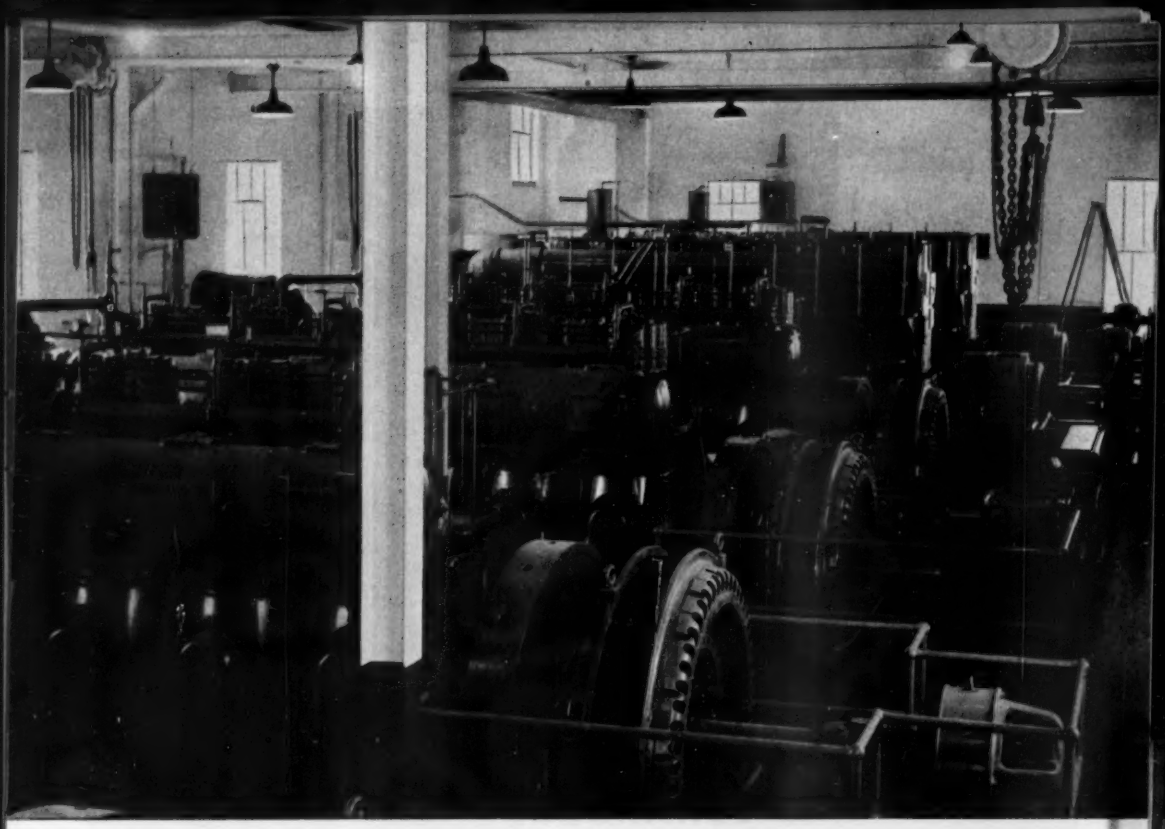
CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

50th DE LAVAL Anniversary



Port carbon, bearing failures, and ring sticking cut to a minimum with...

STANDARD HD
TRADE MARK
Diesel Oil

● Stuck rings plagued the Glidden (Iowa) Rural Electrical Co-operative. Overhauls for the plant's seven diesel engines were necessary every 3,000 to 4,000 hours. Moreover, port carbon had to be removed every 300 hours from some engines. Bearing failures added to the troubles.

But that was all changed, in 1947, when a switch was made to STANDARD HD Diesel Oil.

Ring sticking troubles have been eliminated. The first diesel to use STANDARD HD has now operated 15,000 hours without overhaul and shows no sign of requiring one. Carbon formation has been reduced to the point where it is only necessary to clean ports every 600 hours instead of every 300 hours. Bearing maintenance has ceased to be a problem.

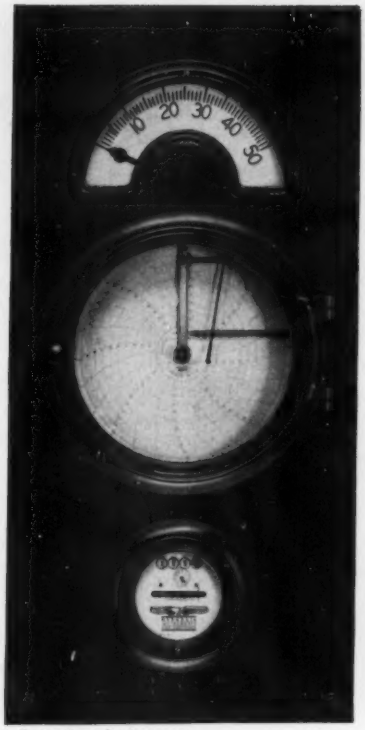
The experience of this diesel operator indicates how STANDARD HD Diesel Oil will help you eliminate costly maintenance and operating problems. A Standard Oil lubrication specialist can show you many plants where STANDARD HD gives this cost-reducing performance.

• • •

Call the nearest Standard Oil Company (Indiana) office, or write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois, for the services of a lubrication specialist.

STANDARD OIL COMPANY (INDIANA) STANDARD

Integrator



Indicator-Recorder-Integrator

Varying flows are accurately totalized because the integrator is continuous

The Republic flow integrator, being of the modified watt-hour type, totalizes continuously—not intermittently. It operates independently of the recorder and its accuracy is not dependent on or affected by any clock mechanism or mechanical action.

The Republic meter is, on this account, peculiarly fitted to follow all changes in flow rate and accurately measure highly fluctuating flows.

ALL TYPES OF FLUIDS

Republic electric type flow meters are available for measuring the flow of all types of liquids and gases. Meter bodies are built for metering fluids at line pressures up to 5,000 lb. per sq. in. and for all ranges of differential pressure. The reading instruments—indicator, recorder and integrator—are of the remote reading type and can be located any distance from the point of flow measurement.

ANY COMBINATION

While each Republic reading instrument is standard in design and construction each is especially calibrated for the particular flow measurement for which it is specified. Any reading instrument, indicator, recorder or integrator, may be obtained separately or in any combination desired, making possible the highest degree of flexibility in plant use.

SIMPLE IN OPERATION

The Republic electric meter is the only flow meter commercially manufactured which is strictly electric in its operation. All other types of so called electric meters use the motion of the mercury to move a float or produce a force which is then converted into an electrical value which is in turn transmitted to a receiving or reading instrument. In the Republic meter, the transmitted electrical value is determined directly by the mercury motion, thus eliminating one of the steps in the sequence, and simplifying the mechanism to that extent. There are no floats, levers, cams, rotating shafts or anything else to interfere with the unimpeded movement of the mercury, which has no work to perform, but merely fulfills the function of making contact.

NEW DATA BOOK

Just off the press—a completely new data book describing and illustrating, in detail, the operating features of the Republic Flow Meter and its many applications. Write for your copy of Data Book No. 702—there is no obligation.

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30 FT. ROLL
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Uskorona combines maximum resistance to OZONE and MOISTURE with high tensile strength, elongation and dielectric resistance. Fuses quickly without heat or pressure and makes PERFECT SPLICES.
MADE IN U.S.A.
United States Rubber Company

USKORONA is the only tape that gives protection against both moisture and corona (ozone). In a test of four leading brands, only USKORONA was unharmed after 4 hours' exposure to ozone. For further proof, the USKORONA sample was exposed for 500 consecutive hours and still no corona deterioration occurred.

USKORONA is easy to splice. Fuses quickly without heat or pressure. The smooth, even, long-lasting splices are especially suited for long underground exposure.

USKORONA has been adopted by many leading power companies for underground connections. Ideal for insulating, joining and splicing almost all terminals, circuits, transformer leads and secondary network systems. For full information write address below.

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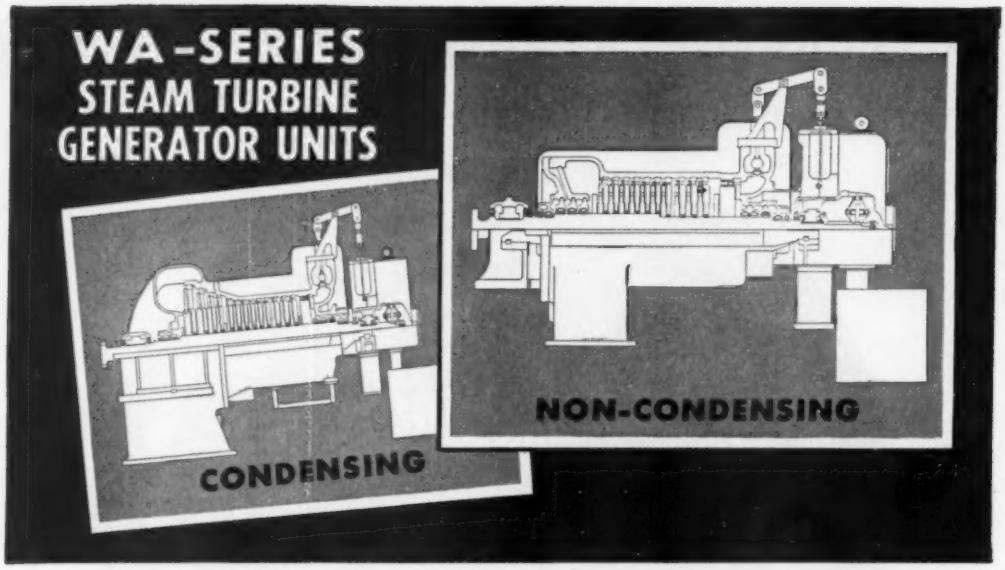

Expanding? The WA-Series will Fit into Your Plant

TODAY INDUSTRY MUST EXPAND while producing at a record rate. To help this vital expansion, Allis-Chalmers offers modern WA-Series steam turbine generator units for industrial and utility steam power plants.

If you prefer high quality construction and modern design, be sure to investigate the recently announced WA-Series, now being built in ratings through 7500 kw. The most recent developments are embodied in this modern impulse design, built for both condensing and non-condensing service, with or without automatic extraction.

Built in NEMA ratings, the WA-Series steam turbine generators are compact, three-bearing, solidly coupled units. They are being built in the condensing type, for power generation only, and in the non-condensing and automatic extraction types, to tie in thermodynamically and provide a steam-power balance where process steam is used.

Design and construction of WA-Series units meet the rigid standards Allis-Chalmers has established for its entire steam turbine line. Just as in the larger steam turbines ranging to 150,000 kw, labyrinth steam seals are used for shaft glands and interstage packing. Corrosion and erosion resistant high chrome alloy steel buckets and nozzles are used throughout in the WA-Series.

WA-Series units are completely coordinated in design. Impulse turbine, housing type air-cooled generator, and exciter are all especially engineered to operate as a unit. *And*, the entire unit is manufactured, assembled, and tested under one supervision at one plant.

Make sure that your next generating unit is *quality* built and has *all* the latest features. Call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-3312

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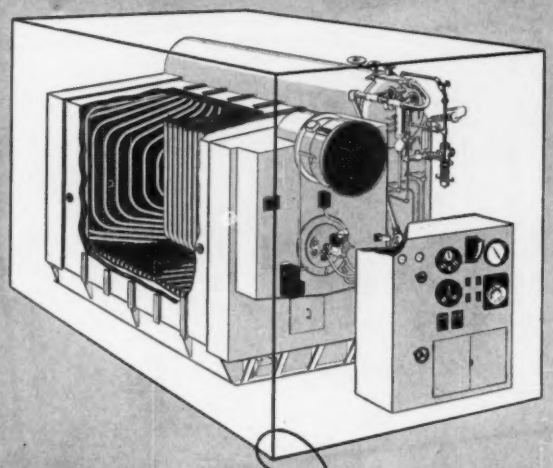
World's Widest Range of Power Plant Equipment

get your steam

3,500 to 25,000 lb per hr



B&W Integral-Furnace Boiler, Type FM

• in this • NEW • shop- • assembled • unit •

- Saves Erection Time and Cost
- Meets Wide Range of Services
- Handles Quick Load Changes
- Fast Steaming
- Low Maintenance
- Easy Accessibility
- Suitable for Outdoor Service
- Burns Oil and/or Gas
- Saves Fuel
- Saves Space
- Safe, Automatic Operation

note these cost-saving features

Send for Bulletin G-72, detailing the many advantages of this new B&W creation in low-cost steam generation. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

Helping Industry Cut Steam Costs Since 1867

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G-536

PINPOINT SKETCH OF INDUSTRY-WIDE SATISFACTION

Photo of 4' x 6' wall map of Nalco Industrial Department. Each pin locates a user of The Nalco System. Pins in Great Lakes are Nalco System ships.

NALCO System installations and ships*—each a pin in the map above—literally blanket the industrial and fresh water navigation areas of our country. The reason is simple: *satisfaction with Nalco chemicals and services.*

If you are not already getting the efficiency and economy of The Nalco System in your plant, now is the time to find out about it. Best Nalco Salesmen are Nalco Users—and there are sure to be several near you. For prompt Nalco Service, call or write today.

**This map does not show the thousands of miles of railroad lines and terminals served by Nalco . . . That requires another large map by itself!*

NALCO CHEMICALS AND SERVICES

- **WATER TREATMENT**—Chemicals and Consulting Services. Boiler feedwater, internal and external, locomotive and stationary.
  Cooling waters.
  Paper and pulp mill processing waters.
  Chemical and Food processing waters.
  Potable waters (slimicides and softening).
- **COMBUSTION CATALYSTS**—SR Series Chemicals for coal and oil fuels.
- **ANTIFOAM AND STABILIZATION** chemicals for water and other liquids in process.
- **LABORATORY RESEARCH**, commercial analyses, consulting services.
- **PAPER AND PULP MILL** pitch and clay control, size control, slime and mold prevention.

Additional information on any Nalco Chemicals and Services will be furnished without obligation.

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THE Nalco SYSTEM...Serving Industry through Practical Applied Science

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

ELECTRICAL

101 **Power and Control Cables**—Sixty-pp Catalog 34 describes typical power and control cable designs and is intended as a guide in selecting proper wire and cable types. Describes insulations, sheaths and coverings, electrostatic shielding, and includes product data on all types listed. A technical section gives standard reel sizes and capacities, standard wire and cable specifications. Generously illustrated with photos showing construction of various types available. Rome Cable Corp.

102 **More Light for Your Dollar**—Eight-pp Bulletin 1B-0323 presents a seven-step light maintenance program to reduce lighting costs and give your plant more light. Covers light meter check-ups, a simplified lamp replacement plan, periodic cleaning schedule, the effect of general decorating on light, reserve stock of parts, proper voltage and labor saving maintenance devices. A practical type of booklet, it's illustrated throughout and worthwhile reading in the interest of economy. General Electric Co.

103 **Manual Motor Starter**—This folder presents a new fractional horsepower motor starter, describing its seven important design features. Operation is explained and both surface enclosure and open-type units are diagrammed. Also included is selection data on choice of correct heater size. Federal Electric Products Co.

104 **Motors and Generators**—Twelve-pp booklet B-4296, describing company's new d-c motors and generators of the Life-Line Type SK series, shows how the new design uses rolled steel frames, heavy steel brackets, steel angle feet and pre-lubricated double-sealed ball bearings. Pictures and discusses use of cast brass brush-holders, stainless steel springs, and Melamine Moldarta molded rocker rings to provide corrosion resistance in brush-holder assembly. Describes unit construction of field coils, and use of Tufvar insulated conductors in the armature. Also shows construction of end turns which causes a fan effect to provide a constant flow of air through the motor to prevent localized heating. Describes type, enclosures, mountings for many applications. Westinghouse Electric Corp.

105 **Ground Testing Instruments**—Comprehensive Bulletin 25 offers 20 pp of likeworthy information on Megger ground testing instruments for measuring resistance of earth to ground connections and for measuring earth resistivity. Aids to proper selection, application, typical tests, drawings and illustrations all help to make this a valuable aid for those concerned with grounding surveys, electrical power and communication grounding, electrolysis and cathodic protection. Bulletin also describes company's new GVM tester, an easily used moderately priced instrument with ranges from 0 to 300 ohms. James G. Biddle Co.

STEAM GENERATION

106 **Packaged Steam Generators**—The questions you ask about a packaged steam generator are answered in Bulletin SB-38 introducing company's new Keystone model. Photos and sketches show complete unit, pressure element and details of its compact design. Text covers special advantages of the two-drum water boiler, three-pass gas travel, automatic gas or oil burner and induced draft fan construction requiring no chimney. Dimensions and capacities listed, equipment described for this conservatively rated, fast steamer. Erie City Iron Works.

107 **Centralized Combustion Control Equipment**—Bulletin 169, 4 pp, presents a line of equipment described as ideally suited to control board arrangement which concentrates vital operating information and controls for one or more boilers, furnaces or process units before a single operator. Describes and illustrates scale unit, indicator, selector valve and remote manual relay. Includes dimensions. Bailey Meter Co.

108 **Feedwater Control**—Recent developments in company's three-element feed water control are described in 16-pp Bulletin 105-C. Provides a straightforward, concise discussion of problems encountered in feed water control and explains how this air-operated three-element system helps solve them. Diagrams, cutaway views, typical chart records and photos of modern installations are included. Bailey Meter Co.

109 **Chemical Feed Systems**—Not a sales catalog, this 12-pp booklet presents an informative technical article covering both dry and solution feeding, discussing the applications and potentialities of each. Illustrated by photos and drawings the text describes variations of the main types of feeding, explains their advantages, limitations, equipment required. Proportioneers, Inc.

VALVES

110 **Forged Steel Valves**—Form 800-A illustrates and describes 800-lb forged steel valves for high line pressure and temperature applications. Covers both inside screw and OS&Y union bonnet gate types, giving dimensions, prices. Special features are described and chart shows trim metals to be specified for different valve parts for different services. The Ohio Injector Co.

111 **Valve Buyers' Guide**—Catalog 56V, 112 pp, describing the company's entire line of bronze and iron body valves, is concise and compiled for easy reference. Listings are complete for valves shown on each page of this handy catalog, and include photos, dimensional diagrams, price, weight, sizes and dimensions, elim-

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mating reference to other pages for these details. A section describing accessories and much essential engineering data is included. Catalog is fabrikoid bound, indexed. Stockham Valves and Fittings.

LUBRICATION

112 Viscosity of Fluids—The larger significance of viscosity is discussed in Nos. 5 and 6, Vol. 36 of Lubrication, a technical publication. In six parts, the first part of the article illustrates the simplest conception of streamline flow between two surfaces having relative motion. A series of torsion viscometers shows how viscosity acts and may be measured. Part II covers streamline flow in capillary and other small tubes. Part III covers turbulent flow usually encountered in pipes. Part IV discusses effects of temperature and pressure on viscosity, and Part V includes viscosity index. Part VI gives a brief reference to the nature of plastic flow. The Texas Co.

113 More Work per Drop of Oil—Illustrated Form 429 introduces company's Micro-Fog, an improved lubricator designed to offer more thorough lubrication and reduced maintenance. Explains principle of operation, describes special features, gives specifications and sizes. Also discusses use of lubricator on various types of equipment. C. A. Norgren Co.

114 Lubricant Data Book—Handy and helpful, this pocket-size 36-pp booklet covers use of company's industrial lubricants. Gives product information and principle uses of approximately 40 lubricants of both grease and fluid types, and gives general directions for proper application. Devotes a chapter to lubricant requirements of equipment in 25 major industries. Also discusses use of heavy-duty motor oil. Lubriplate Div., Fiske Brothers Refining Co.

INSTRUMENTS

115 Liquid Density Meter—A new direct-reading instrument for measuring liquid density is described in 8-pp Bulletin W-2. Designed to eliminate errors caused by liquid and gas interface in many types of instruments, this meter uses a totally submerged, self-centering, chain-weighted plummet as its measuring element. The scale is read across a single reference line on the plummet. Complete specifications, performance characteristics, installation drawings included. Foxboro Thermometer and Instrument Co.

116 Little Moisture Meter—A midget meter for instantly determining moisture content of wood, lumber, plaster and wood products, is described in 6-pp Bulletin 1253. Described as fast, accurate and self-contained, this meter measures moisture by electrical resistance method. Readings are taken directly at the touch of a button in per cent moisture. Its design and construction are explained and its use in testing woodwork, plaster in walls and ceilings described, illustrated. Tagliabue Instruments Div., Weston Electrical Instrument Corp.

AIR HANDLING

117 To Stop Moisture Damage—Automatic dehumidifiers are described and illustrated in two bulletins. One covers a small unit designed for removal of 2 gal of moisture per day; the other covers a larger, three-channel continuous adsorption type unit for removing 14 to 56 gal per day in up to 25,000 cu ft of enclosed space. Operation of both models is explained and illustrated and specifications and performance data included. Dryomatic Corp.

118 Dust Control Technology—Detailed selection, operation, and maintenance data is contained in this 56 pp digest-size book, "Industrial Dust Control through Exhaust Systems." Illustrated with photos and drawings the book treats in its major sections: exhaust hoods and piping systems; dust collecting equipment; exhausters and drives.

Introductory chapters list basic methods of dust control and analyze basic elements of dust control exhaust systems. The part on hoods and piping systems discusses control of air movements, recommended hood and enclosure design, exhaust air velocity and volume and rules for installing system piping. Another section provides descriptive and application information on various types of collecting equipment. Another tells how to determine exhauster capacity and discusses types of exhausters. The final chapter is devoted to operation and maintenance, giving methods for testing and evaluating exhaust system effectiveness, recommendations on periodic check-ups and routine inspections. Pangborn Corp.

119 Larger Portable Compressor—Form 2310 introduces company's Gyro-Flow 600 portable compressor, a new type of rotating vane compressor built to deliver 600 cfm free air at 100 psi and described as the lightest weight unit (9500 lb) of its capacity range. Gives construction and design details, special features of the compressor, pictures its use in a wide range of jobs. Ingersoll-Rand Co.

MATERIAL HANDLING

120 Cranes for Heavy-Duty Work—Fourteen-pp Form 417 on ¼ yd crane-excavators with lifting capacities from 6 to 12½ t. Stresses economy and flexibility of the three models—crawler, truck and wagon,—showing how each is convertible to front end attachments. Gasoline or diesel power is optional. Such features as self-leveling chassis, oversize clutches, right angle drive mechanism are described, illustrated. Specifications and operating data are included. Wayne Crane Div., American Steel Dredge Co., Inc.

121 Hoisting Equipment Reference Book—Product illustrations, complete engineering specifications and list prices currently effective on company's entire line of hoisting equipment are presented in 92-pp Catalog 61. Covers chain hoists, trolleys, cranes, sheaves, hoist chain, electric hoists, winches and cranes. Full data on repair parts for each type of equipment is given. Loose leaf binding permits addition of other pertinent data. David Round & Son.

122 Featherweight Hoist—Form 101, 2 pp, describes a low priced 1½ t capacity winch hoist weighing only 8½ lb. Sketches show the hoist in use on machinery lifting jobs, plumbing work, and heavy duty lifting where use of double cable gives greater capacity. The Lug-All Co.

TOOLS

123 Condensed Data on Pipe Machines—Illustrated Form PM-139, a small folder, packs a wealth of factual information on manufacturer's portable pipe and bolt machines and covers a heavy duty model, utility model, and lightweight economy model as well as power drives, a pipe cutter, pipe threader for use with electric power drives. Beaver Pipe Tools, Inc.

124 Manual on Carbide Tools—Extremely informative and useful, 68 pp Catalog

(Continued on page 114)

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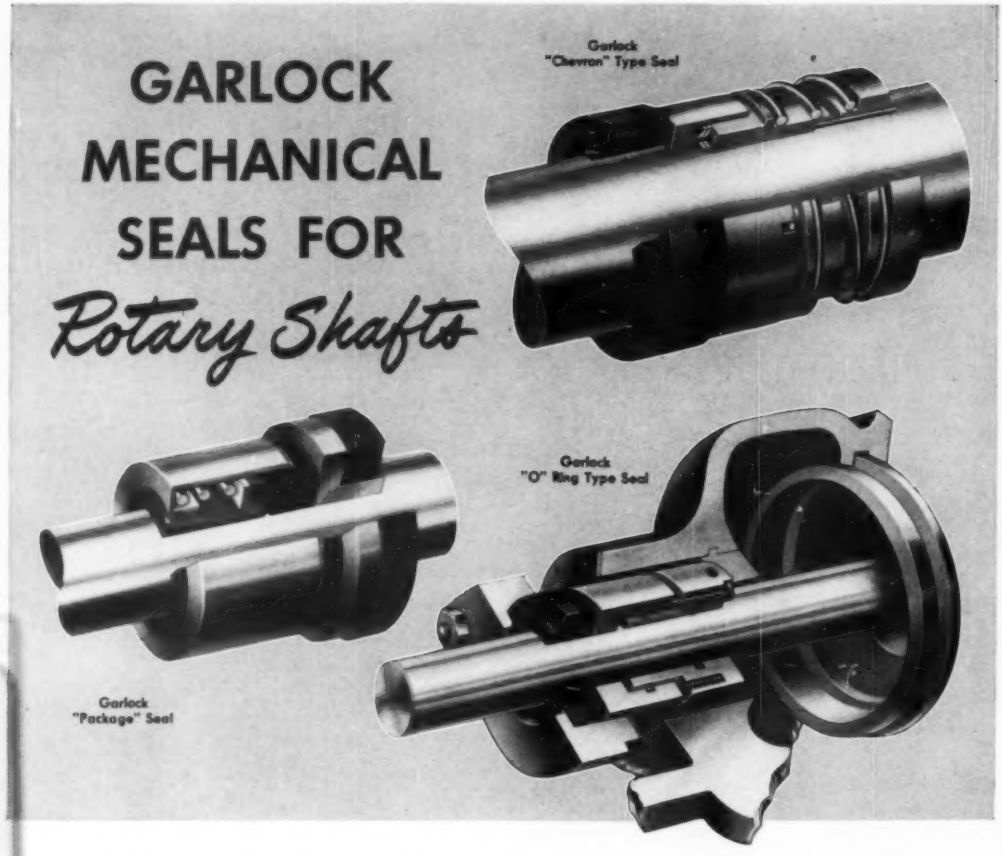
GARLOCK MECHANICAL SEALS FOR *Rotary Shafts*



Where leakless operation of rotary shafts on pumps or other equipment is required, GARLOCK MECHANICAL SEALS will do the job.

There is no wear on the shaft when a Garlock seal is used. Sealing is effected by leakless and positive contact between carefully lapped metal-to-carbon or metal-to-metal mating surfaces. One of these elements rotates with the shaft and the other is stationary. The stationary element does not contact the shaft.

These precision-built seals are made in several standard designs and in a wide range of highest grade materials. The selection of design and materials depends upon the service in which the seal is to be used. If none of our standard designs appears entirely suitable for any specific application, a modification of a standard design or a specially designed seal will be engineered and built for that job.

Thousands of GARLOCK MECHANICAL SEALS have proved their effectiveness, durability and economy on shafts operating at high and low speeds and pressures. Users of Garlock seals are enjoying many months—or years—of trouble-free operation on equipment handling various liquids such as, for example, water, gasoline, beer, acids and paint.

If you need Mechanical Seals for any kind of a rotary shaft application, let Garlock's experienced engineering staff work with you. Write for our Mechanical Seal booklet.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

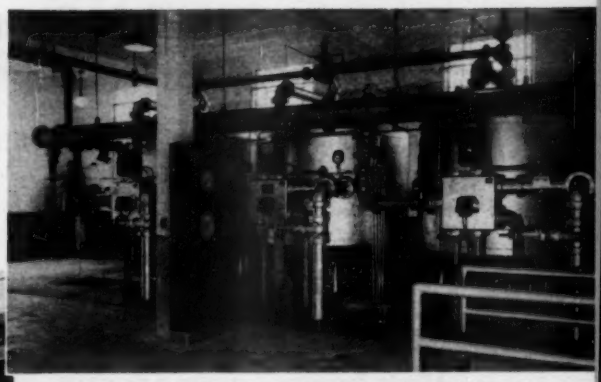
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK

REGENERATED by FATHER NEPTUNE

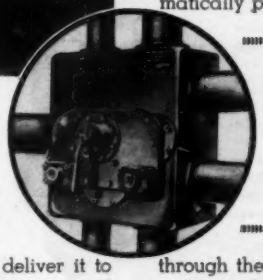
COCHRANE Zeolite Softeners at City of Jacksonville Beach, Florida

(Right) Cochrane Zeolite Softeners. Three units, each with a 6" Hydromatic Valve, arranged for automatic operation



(Below) Cochrane Sea Water Filters, with 6" Hydromatic Valves

The entire plant is fully automatic in its control and in regeneration. Each of the three Cochrane Zeolite Softeners is furnished with a Cochrane 6" Hydromatic Valve, which automatically regenerates the unit after it has softened its rated capacity. The automatic regeneration consists of (1) backwashing, (2) sea water automatically pumped through filters and then downward through the zeolite and out to the sewer, and (3) sea water is rinsed from the zeolite bed by fresh water. After regeneration the unit is automatically returned to service. An electrical interlock prevents more than one unit being regenerated at a time.



The COCHRANE HYDROMATIC VALVE

This remarkable valve combines, in a single pilot-actuated valve, the functions of six individual gate valves, common to the customary "valve nest". It may be arranged for automatic or manual operation.

AN interesting example of water softening by Cochrane Zeolite Softeners is that of the City of Jacksonville Beach, Florida, which recently installed a new softening unit as an addition to the city's existing water plant. Three Cochrane Sodium Zeolite Softeners treat aerated raw water from three artesian wells and deliver it to soft water storage reservoirs, from which it is pumped into the distribution system.

The unique feature of the installation is that the regeneration of the zeolite beds does not come from the usual brine tanks, but is accomplished by means of full strength sea water, which is taken from the ocean and, after clarification by two Cochrane filters, is pumped directly to the softener unit being regenerated.

The savings effected in the cost of salt and salt handling equipment by using sea water for regeneration makes this a most economical installation, even considering the added cost of piping out into the ocean to secure the sea water.

88 YEARS OF SERVICE

Details and literature may be had on request.

COCHRANE CORPORATION • 3123 N. 17th Street • PHILADELPHIA 32, PA.

In Canada: Canadian General Electric Co., Ltd., Toronto. In Mexico: Babcock & Wilcox de Mexico, S.A., Mexico City. In Europe: Recuperation Thermique & Epuration, Paris.

COCHRANE

ZEOLITE SOFTENERS

Important points to know about COTTRELL *Electrical Precipitators*

A COTTRELL Electrical Precipitator is a major plant investment. Once installed it is operated over a period of many years, *thus multiplying year after year the benefits of top notch design and installation.*

And because of the many factors affecting the operating and collecting efficiency of a COTTRELL Precipitator, probably in no other field do the experience and "know-how" of the organization designing and installing the unit play a more important role in influencing the overall performance of the installation. That is why it is so important to remember this fact . . .

Western Precipitation Corporation is the organization that installed the first successful COTTRELL *Precipitator over 39 years ago, still operating efficiently . . . and has consistently developed new refinements, new techniques, new applications that today have made it world famous in the science of recovering dusts, fly ash, mists, fogs and other suspensions from gases.*

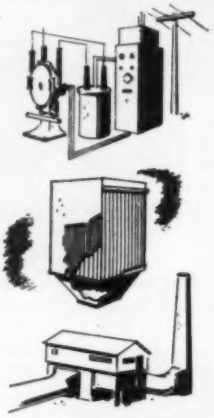
This is the first of a series of advertisements briefly outlining the important elements that go to make up a COTTRELL installation. Only long experience coupled with highest engineering ability, can assure the proper combination of these elements into a COTTRELL installation best suited to *your particular requirements*!

Basically, a Cottrell Precipitator consists of three major divisions each in turn consisting of many separate elements . . .

1. THE ENERGIZING SYSTEM, as its name implies, is the portion of the unit wherein the power is brought in, the voltage stepped up, then rectified to provide the unidirectional high voltage current supply for the Electrode System.

2. THE ELECTRODE SYSTEM consists of the high-tension ionizing electrodes and collecting electrodes through which the suspension-laden gas is passed to be cleaned. These electrodes can be of various designs, shapes and patterns and are equipped with various "rapper" arrangements which assist in keeping the electrodes clean of recovered materials.

3. THE HOUSING OR SHELL includes the structure containing the Electrode and Energizing Systems as well as the gas ducts and distributing system, the hoppers for receiving the collected material and other miscellaneous equipment.



Each of these three major divisions, together with their many individual parts, must be carefully engineered into ONE integrated and precisely-balanced unit to provide the successful and continuously-operating COTTRELL Precipitator. This series will take these major units apart to show in greater detail how the individual parts function and the varying types of design and construction. Watch for them.

10 COTTRELL ADVANTAGES

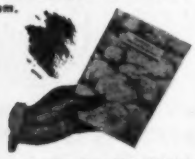
that make Cottrells unsurpassed for all types of recovery problems, hot or cold, wet or dry

1. **LOWEST DRAFT LOSS** — only a few tenths of an inch w. g.
2. **LOWEST POWER COST** — only ½ to 1 kwh. per 100,000 cu. ft. of gas cleaned.
3. **LOWEST MAINTENANCE COST** — all metal, few moving parts, no fire hazard.
4. **LOWEST LABOR COST** — operation can be fully automatic, if desired.
5. **LONGEST LIFE** — early Cottrell installations still operating after 39 years of continuous service.
6. **HIGHEST EFFICIENCY** — recovery efficiency approaches 100%, if desired.
7. **UNIVERSAL APPLICABILITY** — recover any suspension, solid or liquid — in any gas — over wide temperature ranges.
8. **ANY CAPACITY** — handle a few c.f.m. — or millions — with equal ease.
9. **MAXIMUM FLEXIBILITY** — readily adaptable to varying installation requirements.
10. **LOWEST OVERALL COST** — cost less per year of service, less per ton recovered. Often pay for themselves in a few months — always within a few years.

WESTERN Precipitation CORPORATION

ENGINEERS, DESIGNERS & MANUFACTURERS OF EQUIPMENT FOR COLLECTION OF SUSPENDED MATERIALS FROM GASES & LIQUIDS

Main Offices: 1029 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA
CHRYSLER BLDG., NEW YORK 17 • 1 LaSALLE ST. BLDG., 1 N. La SALLE ST., CHICAGO 2 • HOBART BUILDING, SAN FRANCISCO 4, CALIFORNIA
PRECIPITATION CO. OF CANADA, LTD., DOMINION SQ. BLDG., MONTREAL



Do You Have This Helpful COTTRELL Booklet? In 28 pages of interesting charts, illustrations and descriptive data, it answers many of the questions engineers ask about COTTRELL design and construction. Send for your free copy. Ask for Bulletin C103!

BIDDLE

Instrument News

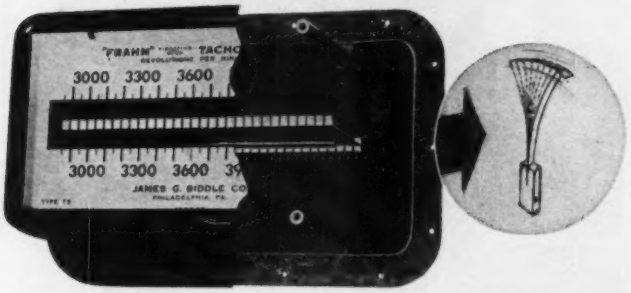
- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

NUMBER 4 OF A SERIES

JAMES G. BIDDLE CO., 1316 ARCH ST., PHILADELPHIA 7, PA.

THE FRAHM® RESONANT REED IS THE "NATURAL" WAY OF MEASURING SPEED

No Oiling • No Maintenance • Imposes No Load on Machine Under Test



The speed measuring device in a Frahm Tachometer is extremely simple. It consists of a set of consecutively tuned spring steel reeds mounted in a case with a scale calibrated in rpms or vpms. The predominantly vibrating reed indicates speed at a glance. The principle is based on the natural phenomenon of resonance—the quality of an elastic body to vibrate vigorously when subjected to small rhythmic impulses at a rate approximating its natural frequency. No rotating machine is absolutely free of vibration. However imperceptible, the vibration can be measured with a Frahm Resonant Reed Tachometer by touch or permanent mounting. (The same principle is used to measure and indicate electric frequency.)

Guaranteed Accuracy

Careful research and many years of practice in the art of manufacturing and tuning reeds enables our craftsmen to guarantee accuracy to within 0.5% of the rated frequency of vibration.

Ranges from 1,000 to 100,000 RPM

Frahm Tachometers offer dependability and long life for measuring speed or rate of vibration in a variety of ranges from 1,000 to 100,000 rpm or vpm.

We are constantly publishing new technical bulletins on Biddle Instruments. A complete list of our latest bulletins will be mailed you on request, so that you may check it to bring your files up-to-date.

SEND FOR NEW 16-PAGE BULLETIN

Just off the press, with the latest designs and specifications for Frahm Tachometers. Various shapes, sizes and applications are recommended.

Ask for Bulletin 31-PE or mail convenient coupon. Your correspondence is invited.

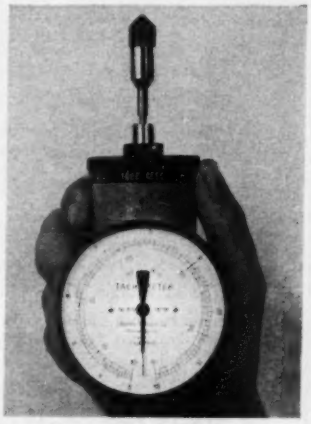
BULLETIN 31-PE

REDUCE COST OF TACHOMETER REPAIRS

—Keep Them on the Job Longer

The new Jagabi® single, and multi-range tachometers remain on the job longer and cut repair costs in half because they now include overspeed protection.

Incorporated in these latest instruments is a clutch device which *minimizes* the harmful effects of overspeeding and too-sudden acceleration.



This feature is unique in the Jagabi Tachometers and worth many times the very small initial cost. Longer instrument life and far fewer repair bills mean reduced expenses for you. One, three and five-range instruments are available in a variety of ranges from 25 RPM to 48,000 RPM.

Write today for Bulletin 35-PE for complete information including prices.

JAMES G. BIDDLE CO.
1316 Arch St., Philadelphia 7, Pa.

Date _____

Please mail me your new Bulletin 31-PE ☐
Bulletin 35-PE ☐
List of Bulletins Available ☐

_____

Name _____ *Position* _____

Company _____

Address _____

No Other Water Conditioning System Has All of These Features...

...ALL IN ONE TANK:

YES, you get all these and more, too, in one tank without the aid of internal mechanical agitation or other moving parts when a water conditioner like this 900,000 lb. per hour Worthington installation treats your make-up or condensate water.

In less space you get all the heating, chemical feeding and clarification facilities to provide optimum water conditioning results. Worthington's engineering skill and complete manufacturing facilities offer you the advantages which can only result from carefully coordinated effort under one responsibility.

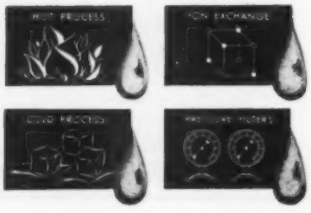
WRITE FOR FACTS

For proof that, in water conditioning as in so many other services, *there's more worth in Worthington*, write for Bulletin W-212-B2. *Worthington Pump and Machinery Corporation, Water Treating Division, Harrison, N. J.*

Main treating tank of a Worthington Hot Process Water Conditioning System, capacity 900,000 lb. of treated water per hour

Six pressure filters 11 feet in diameter used for final clarification in this Worthington Hot Process Water Conditioning System

J8-3



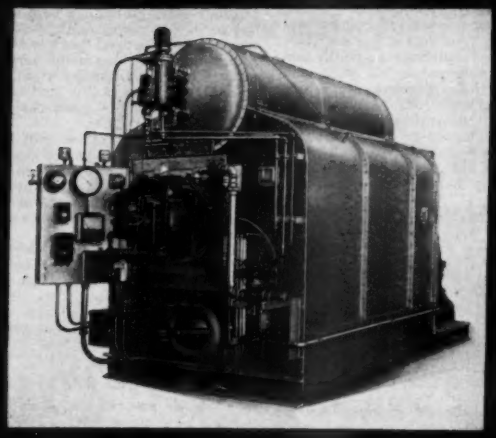
WORTHINGTON

WATER CONDITIONING

Worthington Makes* More *of the Equipment For All Types of Water Conditioning Systems

Here's What You Get...

for your KEYSTONE *dollar*



Compact Design—The Keystone packs large steam capacity in small cubage, because of its unique furnace, contained within a low-head 2-drum water tube boiler.

Conservatively Rated—The Keystone offers unusually large heating surface per developed horsepower. Ratings are based on 5 square feet per developed horsepower—accepted practice in water tube boiler design.

Fast Steamer—The Keystone is highly responsive to changing load demands, for hot gases travel 3 lengths of the furnace, contacting 5 bare metal heat absorbing zones. Big boiler performance in small space.

Centralized Control—All specified instruments and controls, factory assembled, and mounted on a central instrument panel. All electrical connections to terminal blocks eliminate inter-connecting field wiring.

Automatic Burner—The Keystone is equipped with fully automatic burner for gas, oil or for both interchangeably.

Insulated Steel Casing accurately fitted to reduce radiation losses and air infiltration—removable panel type—all tubes accessible.

Combustion Control—interlocked electrical controls, steam pressure actuated for smooth adjustment of fuel, primary and secondary air supply to obtain most efficient high and low flame position.

Induced Draft equipment is of low speed, conoidal type with automatic damper control on panel.

Safety Controls include automatic cut-offs for high pressure, low water, flame failure, induced draft failure and fire switch.

Easy to install—easy to maintain—Keystone requires no special foundation or stack—just set in place and hook up service connections. Wind box is hinged for easy furnace inspection, hinged burner swings out for inspection—removable side panels give access to any tubes—manholes provide access to drums and tubes.

ERIE CITY IRON WORKS *1413 East Ave.* **ERIE, PA.**

NEW EQUIPMENT NEWS

WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 37-38.

1—TILTING MOTOR BASE

For fractional horsepower motors, is adjustable, and costs only $6

New, lightweight, adjustable, tilting motor base for use with fractional motors up to one horsepower has been developed. It is adjustable in width and length to accommodate all sizes and types of fractional horsepower motors.

This manufacturer claims that this new base is the world's lowest-priced adjustable motor base. In addition to using it with variable speed pulleys, it also acts as a belt tightener and can be used for easy belt changing on cone

step pulleys. Speed changes can be made while machine is in operation. It constantly maintains the correct belt tension and correct alignment. Exact speed control is easily obtained by simply turning a handle screw adjustment.

This new tilting base (patent pending) is 5½ in. by 7 in. in size and the shipping weight is 10 lb. Lovejoy Fexible Coupling Co.

2—POWER PACK

For lighting and power service, 15 to 100 kva, equipment in one metal case

New "midget" load center unit substation, specially designed for low-voltage, regulated a-c lighting and power service in factories and laboratories is shown here.

Called an Inductrol Power Pack, the unit incorporates in one steel housing an air circuit breaker, a dry-type transformer, and an air-cooled induction regulator.

The new pack, available in either single- or three-phase ratings, has a capacity ranging from 15- to 100-kva, with incoming circuit rated 480 to 600 v, 60 cycles, and a regulated output at 120/240 or 208Y/120 v.

With these power regulating units, power can be brought to the load area at relatively high voltage with substantial savings in cable. At the load center, the voltage is stepped down to the value required by the load being served and automatically maintained at that level, to assure maximum life and optimum performance of the connected equipment.

Inductrol Power Pack can also be used to regulate the power supplied to resistance heating and infrared heating equipment, electronic apparatus, precision instruments and control circuits, and commercial electric cooking equipment.

The power pack is completely metal-enclosed which permits it to be installed in any indoor location without the expense of fireproof vaults. Compact and easily installed, the unit can be mounted overhead to save floor space. Unit Equipment Div., General Electric Co.

3—CLUTCH AND BRAKE

Is air powered, designed for accessibility, safety, long wear

New combination friction clutch and brake unit, air powered, for the driving of medium and heavy machinery, has been developed. It is built for accessibility, so that shoe and lining assemblies can be changed in minutes rather than hours, such changes may be made without removing the unit from the machine, all other wearing parts may be removed while the clutch is mounted on the machine, without special tools or removing other parts.

Rivet heads cannot come in contact with the discs, which are securely bolted into place. Mechanism is so designed that linings are positively and automatically withdrawn from contact with discs, eliminating drag. It is impossible for brake and clutch to be engaged simultaneously.

Safety features are: one-piece construction, with the brake operated by pre-loaded springs, to assure positive and immediate stop in the event of air-supply or electric-current failure. Entire unit is controlled by a solenoid valve.

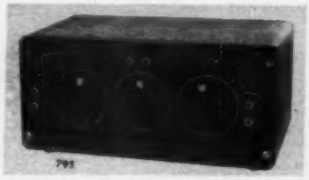
Manufacturer provides an exchange system for clutch and brake shoes. Linings are riveted at the plant, and replacement shoes are shipped to users when needed. Power Presses, Inc.

4—ATTENUATORS

Designed for carrier frequency and network application

Two new attenuator units—the RF Attenuation Network and the Carrier Frequency Decade Attenuator—have recently been announced.

The RF Attenuation Network, Model 650, is incorporated in an RF Attenuation Box. It is built for many applications where attenuation of UHF is desired, since it can be used as an all-



purpose laboratory and test instrument. This unit has a flat frequency response from d-c to 225 megacycles. Insertion loss is zero over the entire frequency range. This model, number 650, has a total of 100 db in 1 db steps. Resistors are calibrated to an accuracy of ±2 per cent at d-c. Impedance of 50 or 73 ohms are standard, and units are available with type N or BNC connectors. Attenuation is inserted in the circuit by means of special push-button type switches, which are mechanically independent of each other. The electrical network is purely resistive, and no compensation is required.

Carrier Frequency Decade Attenuator, Model 795, is designed to be particularly applicable to extremely accurate measurements from d-c to 200 kc and can be used up to the lower radio frequencies. The Rotary Decade type switches are used, and there are switch stops to prevent return from full to zero attenuation when making adjustments. A total of 110 db is available in 1. db; or 111 db is available in 0.1 db steps. Each individual resistor is adjusted within ±0.25 per cent of its correct value. At frequencies below 200 kc, the total error in attenuation will not be greater than ±1 per cent of the indicated value.

Both models available in either a balanced H or an unbalanced T network. The Daven Co.

5—OSCILLOGRAPH

Designed for study of pulse wave forms, operates at 12,000 v

The new Type 294 Cathode-ray Oscillograph is especially designed for accurate study of pulse waveforms. The Y-axis amplifier has been designed with extreme care so that an input-pulse rise-time of 0.01 microsecond will be reproduced with a rise time not exceeding 0.03 microsecond, while the general purpose utility of the instrument is extended to operation at sinewave frequencies beyond 20 megacycles.

Deflection capacity provides 1.7 in. of undistorted deflection for unidirectional pulses, and 3.4 in. for symmetrical signals. Thus, in addition to insuring faithful reproduction of waveforms, full advantage is taken of the usable scan of the instrument's cathode-ray tube.

The Type 5XP-high-voltage cathode-

piping repairs cost more now!

You make them less often by using Dependable Quality

CRANE VALVES

...That's why more Crane Valves are used than any other make

No. 488 Iron Body Clamp Gate

easy access prevents trouble with this valve

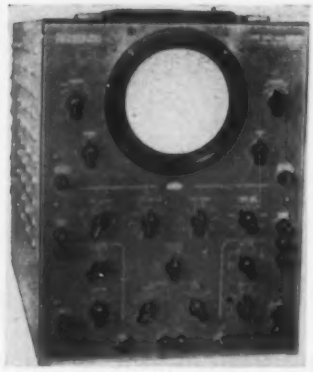
Remove just two nuts to dismantle this gate valve for inspection, cleaning, or repairs—without taking it from the line. Reassemble just as easily, knowing that Crane clamp design keeps the bonnet joint snug and accurately aligned. Use Crane Clamp Gates on steam, water, and air, but especially in heavy fluid lines needing periodic cleanout. They'll save time, labor, and encourage regular servicing that prevents valve trouble.

Combining easy access with highly dependable service features, Crane Clamp Gates typify Crane Quality—*better valve performance at lowest ultimate cost.*

CRANE

CRANE CO., *General Offices:*
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING



ray tube is operated at 12,000 v, making possible the fast sweep speeds necessary to display transient pulses of exceedingly short duration and insuring sufficient light output to record such transients with an oscillograph-record camera. For applications where additional sensitivity and deflection is advantageous, the accelerating potential may be lowered to 7000 v by means of a rear-panel switch.

Recurrent sweeps variable in frequency from 10 cps to 150,000 cps, and driven sweeps variable in duration from 0.1 second to 2 microseconds, are provided. Maximum sweep-starting time of 0.15 microsecond and signal delay of 0.25 microsecond insure full display of steep-wavefront pulses. In conjunction with driven-sweep operation, external circuits may be initiated by a trigger generated and supplied by the Type 294.

Timing markers, particularly valuable when making permanent photographic records, are provided in intervals of 1, 10, and 100 microseconds. The instrument is equipped with a Du Mont Type 2501 Bezel for mounting either the Type 314-A or Type 271-A Oscillograph-record Camera. Allen B. Dumont Laboratories, Inc.

6—METAL CALCULATOR

Is handy way of finding weight and length for all strip metals

This precision instrument is designed to compute, "at a glance," the weight and length of strip metals in coils or straight lengths. Although designed so that basic calculations are for cold-rolled strip

steel, a factor table is included which enables the user to find his answer for aluminum, brass, copper, magnesium, Monel, zinc, and many other metals.

Believed to be the most complete calculator of its kind, it can save time and money by actually lopping hours from jobs where conventional computing methods are used. It can be used by engineers, estimators, purchasing agents, press room foremen, slitter operators, and the like. Free upon request. Precision Steel Warehouse, Inc.

7—WELDING CONTROL

Low capacity for spot welding, can be mounted on or near machine

New synchronous and non-synchronous control equipment for low-capacity, spot-type resistance welding machines is now available.

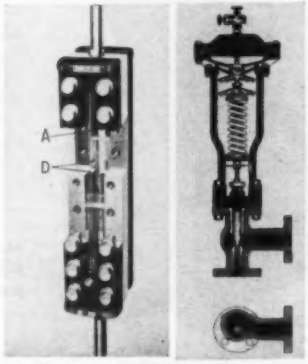
Air-cooled thyratron tubes make and break the welding current, with no moving parts. All components in each equipment are mounted on a side-swinging panel, enclosed in an NEMA type I enclosure for ease of inspection and maintenance. The units can be mounted on or near the welding machine. Knockouts are provided in the enclosure to facilitate making external electrical connections.

Synchronous units can be supplied in rms current ratings up to 50 amp at a 10 per cent duty cycle. Non-synchronous units are available in ratings up to 100 amps at 10 per cent duty cycle. Westinghouse Electric Corp.

8—WATER LEVEL GAGE GASKETS

Are special non-stick type intended for use with high-pressure gages

When glasses or gaskets of high-pressure water level gages are replaced, Yarway flat-glass inserts are now fitted, as shown in the accompanying view, with improved gaskets coated with special compound that prevents adhering to the gage metal surfaces under high pressure and high temperature service. This Frelon gasket is the molded pressure-sealed gasket (D) located in the grooves of the gage insert body. Illustration shows other details of the Yarway pressure-sealed "floating assembly" flat-glass water level gage. Yarnall-Waring Co.



9—REGULATING VALVES

For steam, water and especially for flashing condensate. Size 1 to 4 in.

Complete new line of flow regulating valves, Type V10, is designed to handle steam and water at high pressure drops, and especially flashing condensate. Uses include drainage for stage heaters, evaporator coils, flash tanks, process systems, subcooled heaters, boiler blowdown, feed pump recirculation and other severe service conditions where high-velocity impingement causes frequent maintenance or complete valve replacement.

Seat, disc and long guide sleeve of these valves are made of stainless steel, which has been heat treated and ground to precision fit. Valve design, with scroll inlet and gradually-expanded straight outlet, is intended to eliminate direct impingement and resulting corrosion-erosion effects.

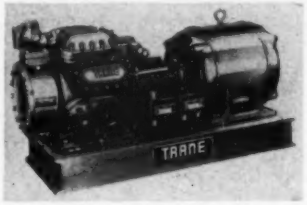
Valves are supplied in seven pipe sizes ranging from 1 to 4 in. All sizes can be furnished in 150 to 600 psi standards; 950-1500 and 2500 psi standards also available. The Swartwout Co.

10—COMPRESSORS

In 10 to 50 ton capacities, for comfort conditioning installations

Designed for quiet, vibration-free operation and low operating and maintenance costs, a new line of reciprocating compressors are built in 10, 15, 20, 25, 40 and 50 ton capacities. Compete condensing units are also made in each size.

Contributing to smooth operations are: cylindrical body design; "V" and "W" arrangements of the four, six and



eight cylinder models; counter balancing of all reciprocating forces; static and dynamic balancing of crankshafts, and reduction of moving weight through aluminum pistons and connecting rods.

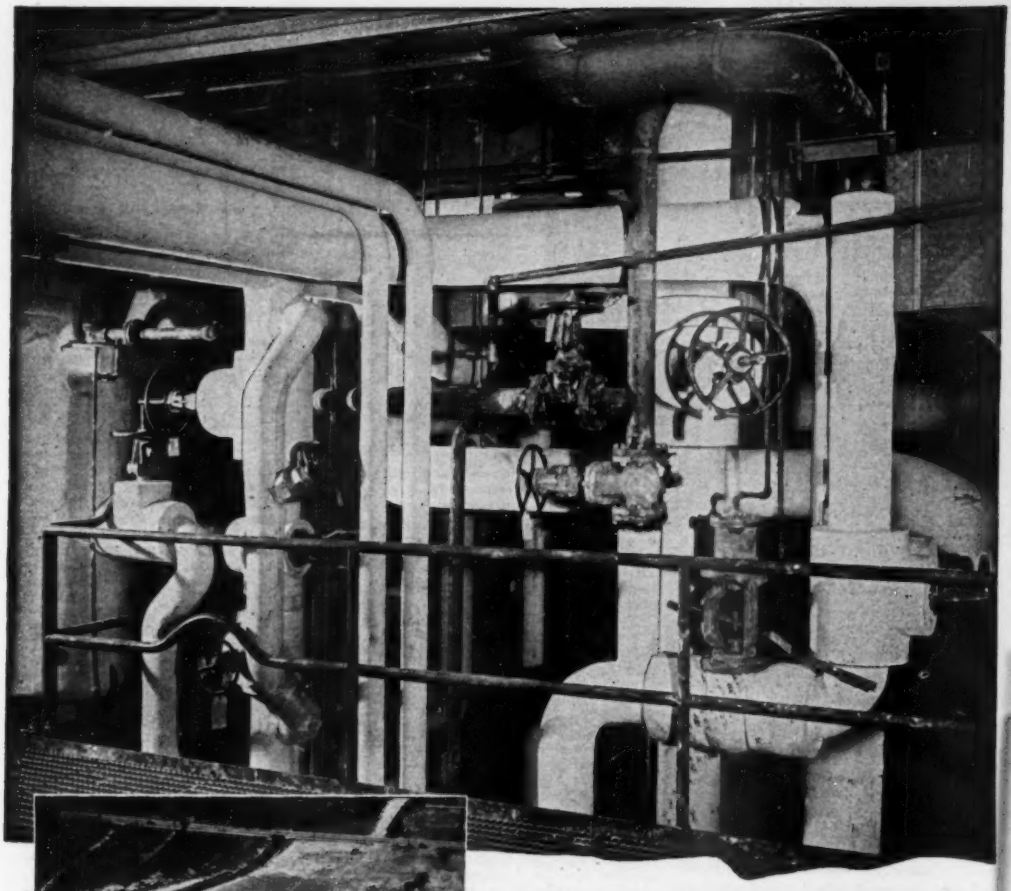
Noise level is from 2 to 10 decibels below other compressors tested in company laboratories, actually below that of the average office. Noise is reduced through use of plastic cushioned valves, aerodynamically designed suction and discharge gas passages, and location of all parts of the capacity control system within the cylindrical body.

The completely automatic, internal multi-step capacity control or "unloading" system is provided. Enclosed force-feed lubricating system and crankshaft oil passages are designed so that centrifugal force carries foreign particles away from bearing surfaces, trapping them against magnetic plugs. All oil is filtered twice before reaching bearing surfaces. This reciprocating line is designed for operation with Freon F-12 refrigerants. The Trane Co.

11—PUMPS

In two types, with capacities to 3000 gpm, for pressures to 250 psi

Screw and Rotex Pumps of recent development are now available in a recent addition to manufacturer's line of centrifugal and reciprocating Pumps. Both are built in two standard types: gear-in-head, and external gear and bearing. Each can be furnished for either hori-



WITH NAVCO PIPING *Results* ARE PRE-ASSURED

Navco's high degree of engineering skill and use of the most modern plant and field facilities are your guarantee of a long lasting and trouble-free piping system.

Consult Navco for Your Next Piping Job

NAVCO

NAVCO PIPING

NATIONAL VALVE & MANUFACTURING COMPANY • PITTSBURGH, PA.

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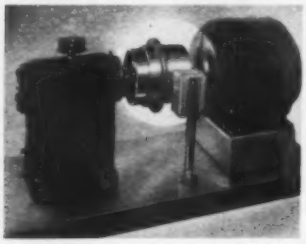
zontal or vertical mounting and in a variety of machinable metals or alloys. Screw types are available in capacities up to 3000 gpm and pressures up to 200 psi on low viscosity liquids and for practically unlimited high viscosity liquids which will flow into the pump inlet. Rotex Pumps have capacities up to 100 gpm and pressures up to 250 psi in the smaller sizes for fuel oil service and similar conditions. Larger sizes are limited to discharge pressure of 100 psi. Warren Steam Pump Co., Inc.

12—CUT-OUT COUPLING

Is a flexible coupling for machines that shuts off power on overload

New automatic device for machine tools, processing equipment, conveyors, is built to shut off the power instantly when an overload due to any cause occurs, and to reset itself automatically preventing sheared pins and saving the time normally required to replace them.



It is designed to combine the features of a flexible coupling with the torque sensitive protection of company's cut-out pulley.

These couplings are furnished in two sizes and with working ranges from 20 to 10,000 in.-lb. torque. Anchor Steel & Conveyor Co.

13—D-C POWER SUPPLY

Utilizes selenium rectifier stacks; for indoor use; convection or fan-cooled

A new line of standard, metal-enclosed d-c power supplies utilizing selenium rectifier stacks has been announced.

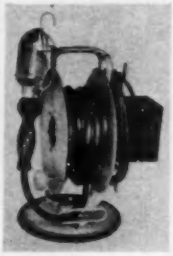
Applicable wherever d-c power is required, the new conversion equipment may be used for excitation of synchronous motors; operation of d-c elevators, cranes and machine tools; and for conversion of a-c feeders to d-c.

Designed for indoor installation, the rectifier units are mounted in a metal casing consisting of one to four separate sections, mounted vertically, one on top of the other, and bolted together. A removable front, wire-mesh panel permit easy access.

The new units can be furnished to supply either 125 or 250 v d-c from a 208-, 230-, or 460-v, three-phase, 60 cycle a-c supply. Convection-cooled equipments are available in ratings of 0.75, 1.5, 3, and 5 kw. Fan-cooled units are rated at 7.5, 10, 12.5, 15, 18.5, 20, and 25 kw. When larger ratings are required, two or more rectifier units may be connected in series and/or parallel to increase the current or voltage rating of the installation.

Under proper operating conditions, the efficiency of these units, when new, will run as high as 81 to 84 per cent, with a power factor of 95. Reliable control and operation is assured by built-in contactors with thermal overload protection and fused disconnect switches.

Built without moving parts, except for the fan in the higher-rated units, the power supplies are expected to need little maintenance. The fan requires greasing approximately twice a year. Lighting and Rectifier Divs., General Electric Co.



14—TROUBLE LIGHT

Is a low-voltage safety lamp with reel for holding extension cord

Damp and wet locations, such as cellars, and inside of boilers and furnaces, offer a ground and conductor to workers there, so that electrical current from a 110-v lamp could be sufficient to cause the worker's death from electrical shock.

The National Safety Council has recommended that for greatest protection, a maximum of 32 v or less for extensions be used in hazardous locations. They have also stated that the safest trouble lamp is preferably one operated from a 6-v lamp.

The Saf-T-Lite, shown here, is such a low voltage lamp. In many industrial plants, public utilities, railroads, hotels, etc., it is now standard equipment, having replaced the old 110 v trouble lamp.

This new model has just been announced and is to be known as the Etraco Reel-Lite. It employs a well-known reel for holding the extension cord, is available in several different sizes with extension cords of 50 and 100 ft. Etraco Manufacturing Co.

15—PIPELINE COUPLING

Has high safety factor—cuts shut-down time—pressures to 1200 psi

New Weld + Ends Coupling is designed for quick, safe and economical rejoining of crude oil, gasoline, L. P. gas and gas pipelines. It is of special design and construction to permit the effective sealing of pipe from 2 in. to 36 in. in diameter in a matter of minutes. Full pipeline pressure can be restored immediately and welding done after line is back in service.

Safety feature of the coupling makes it possible to rejoin high pressure steel pipelines under hazardous conditions without using a torch, by use of a mechanical seal with neoprene rings. No more hot tie-ins on gas lines or bell hole explosions due to leakage. Then, too, if ground is soaked with liquid petroleum, oil or gasoline, welding may be delayed for weeks, if necessary, until the area is weld-safe. Couplings are designed to withstand pressure of 1200 psi indefinitely when set manually and much higher pressures after welding.

When used along with company's pipe saw it is possible to cut a section out of a pipeline and insert a new section without lighting a torch or having an open flame on the job. The E. H. Wachs Co.

16—V-TYPE PACKING

Made of Teflon in V-rings to give frictionless, chemical-proof packing

A V-type Teflon packing, recently announced, is designed to combine the advantages of Teflon as a packing material (chemically inert, heat-resistant, anti-hesive, tough) with a design to give the solid Teflon unusual mechanical resiliency, permitting a tight seal at low gland pressure. Light gland loading, plus Teflon's natural slipperiness, greatly reduces the torque required to operate the valve, and through packing, it is stated, will not "freeze" a valve no matter how long it may remain unoperated. This packing cannot be attacked by any chemical, it is claimed, cannot contaminate any process material, is serviceable throughout the temperature range of —150 F. to 550 F. Chemiseal #810V packing, as it is called, is for application to hand-, air-, or motor-operated valves; for emergency shut-off service; for slow-speed reciprocating pumps—especially where corrosion or chemical attack is a problem.

It is supplied as a series of V-shaped rings. Under compression in the stuffing box, each ring acts as a wedge, forcing the lips of the next ring tightly against spindle and stuffing box.

Supplied in sets or bulk to meet specific requirements, packing is available with square-end adaptors if desired, although they are not especially recommended. Rings may be split for assembly if necessary without harming the packing. Teflon Products Div., United States Gasket Co.

17—HIGH-PRESSURE VALVES

Of shut-off and 4-way types for pressures up to 6000 psi

By use of the 'Shear-Seal' principle, a new pressure-balanced, self-aligning, tubular valve has a seat designed to keep perfect intimate contact with the matting surface of an optically flat porting disc. Rotary movement of this disc (or rotor) opens and closes the flow passages. During the absence of fluid pressure a heavy marcel springwasher maintains the contact between sealing surfaces, while a predetermined hydraulic force acts on the seal under extreme pressure. Fluid flow is always through the hole, never across sealing surfaces, important in the control of dirty high velocity fluids, to eliminate the problems of scoring and wire drawing.

Production models cover a complete range: shut-off valves from ¼ in. to 1½ in. for pressures 0 to 6000 psi; 4-way selector valves from ¼ in. to 1½ in. for pressures 0 to 6000 psi; 4-way dual-pressure valves in two classes, for

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In your plant, large investments in machinery ride on a thin film of oil. Failure of this film means catastrophe. Perhaps, too, thousands of man hours can be wasted by an inadequate cutting oil. Or the best of raw materials can become inferior end-products because of a poor process aid. You are assured against such losses when you use Sun "Job Proved" Petroleum Products. Here's why . . .

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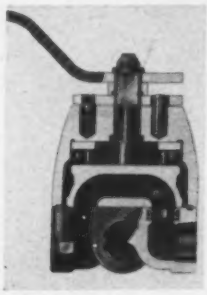
3000 psi maximum pressure, and for 6000 psi maximum pressure; manipulator valves from ⅜ in. to 1 in. for pressures 0 to 1500 psi. The service ratings include all common industrial media such as water, air, hydraulic oil, gas, fuel and petroleum.

Rotors are hardened corrosion resistant steel castings with smooth rounded flow passages that minimize



resistance and turbulance. In the 4-way valve, the rotor is constructed to allow for a switch of the same valve from "open center" to "closed center." Bodies are high tensile hydraulic bronze and available with regular in-line porting, straight, or manifold porting. Housings are corrosion-resistant meehanite designed for flexibility in mounting. The same valve may be table, bracket or panel mounted. Barksdale Valves.

18—DUAL-FUEL DIESEL

Rated at 201 hp, with new design of parts, is 6-cylinder, 4-cycle unit

New diesel power unit, the Mogul Six, of 1905 cu in. displacement, and carrying a maximum continuous output rating of 201 hp with overload capacity of 272 hp, is now in production.

The Mogul Six is a 6-cylinder, 4-cycle, solid-injection full diesel with a bore of 7-in., stroke of 8¼-in., and displacement of 1905 cu in. Recommended for use with all modern, "high speed diesel fuels" of 45 cetane or above. A quick-conversion kit is available to convert this engine in the field, from diesel to natural gas, and vice versa, without any internal parts being changed.

Some of the features the makers claim make this an outstanding engine for independent light and power plants are its massive alloy steel, seven-bearing crankshaft with vibration dampner and hardened journals and crankpins; its hardened wet sleeve cylinders; oil-jet piston cooling and aluminum alloy pistons; full floating piston pins; rifle drilled connecting rods; full pressure oiling; full-flow series connected oil cooler; stellite faced valves and stellite seat inserts throughout; American-Bosch injection system with single orifice pintle nozzles; and provision for

either gasoline engine or electric starting. Waukesha Motor Co.

19—PORTABLE COMPRESSOR

Has rotary air compressor driven by diesel engine to deliver 600 cfm of air

New type of large-size portable air compressor. It features a rotary type compressor. The unit is designated as the Gyro-Flow 600. It delivers 600 actual cfm free air at 100 psi. Total weight is 9,500 lb ready for use, making the Gyro-Flow, it is claimed, the lightest-weight portable compressor in its capacity range. Major advantages claimed by the manufacturer are simplicity and low cost of operation and maintenance, greater reliability, lighter weight, and a discharge temperature at least 100 F lower than that of conventional portables.

The compressor itself is an advanced-design, two-stage, oil-cooled rotating-vane compressor. It contains no pistons, con rods, valves and no need for a clutch. Air is discharged at less than 200 F under normal operating conditions. This, together with thorough oil separation, eliminates hose deterioration caused by heat and oil.

The unit is driven by the General Motors Series 71 diesel engine, 6-cylinder, a two-cylinder engine with 12-v battery starting and fast-starting ether system for cold weather operation. Uniflow scavenging is used to assure complete combustion at all speeds and cool valves, pistons, cylinder liners and heads.

Air-Glide Capacity Control is a new development combining variable intake unloading of compressor and floating-speed control of engine to hold steadier and higher air pressures. According to the manufacturer, the compressor is controlled smoothly and automatically over the full range from 0 to 100 per cent capacity and allows only a 10-lb fluctuation of pressure. Compressor and engine speed always stay just high enough to maintain the desired air pressure.

Separate engine and compressor stack-type air filters are easily accessible for frequent servicing when necessary on extremely dusty jobs. Eight-hour capacity fuel tanks are standard equipment, as are automotive steering, spring mounting, parking reflectors and mud guards. Ingersoll-Rand Co.

CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

WATER TREATING, CORROSION PREVENTION

201 **Water Conditioning Bulletin**—This is an 8-pp discussion of water and the chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Wright Chemical Corp.

202 **Boiler Water Manual**—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-pp technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater system. Also discusses condensate returns, flushing periods. %Proportioneers, Inc.%

203 **Water Softening Equipment** — How the problems caused by hard water can be offset by the use of water softeners is explained in Bulletin 2386, 12 pp, describing ion exchange equipment. It covers in detail downflow, upflow and gravity zeolite water softeners. Contains a 2-pp cutaway illustration of a fully automatic softener. The Permutit Co.

204 **Water Treatment** — Bulletin 5000, 24 pp, explains the reasons for boiler water treatment and tells services offered by company in providing formulations to suit individual plant requirements. Covers pre-treatment, internal treatment, treatment application, blowdown adjustment and test control. Filled with photos and layout diagrams, this helpful booklet also describes available equipment and includes a reference bibliography of literature published on specific formulations. Dearborn Chemical Co.

205 **Boiler Corrosion**—A 12-pp article discussing the cause and prevention of corrosion in boiler systems is presented in Betz Technical Paper No. 111 titled "Corrosion: Its Effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. W. H. & L. D. Betz.

206 **Turbine Blade Deposit Study**—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in 16-pp Bulletin 28B7030. Describes x-ray diffraction methods for identification purposes. Tables list partial chemical analyses of deposits containing sodium disilicate, occurrence data on compounds found, composition of deposits. Allis-Chalmers Mfg. Co.

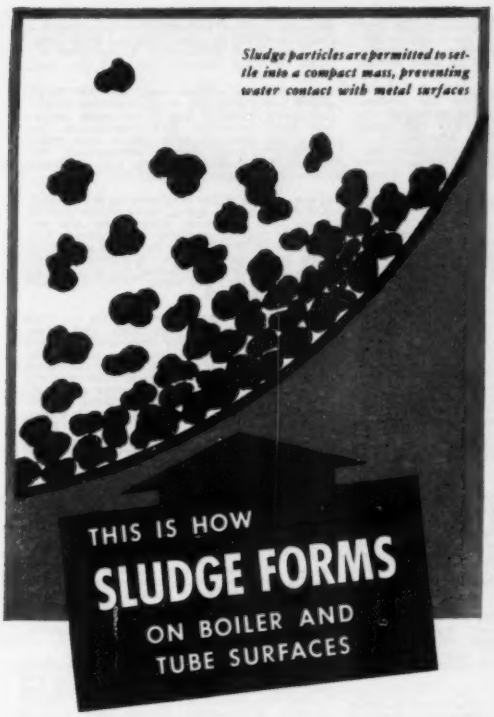
207 **Two-Stage Water Conditioner**—Bulletin 4801 describes company's water conditioner which combines the advantages of both hot process and zeolite softening. Explains operation of softener in which the first stage is the hot process using lime or Dolomitic lime and the second stage in which zeolite softener reduces hardness to zero. Cochrane Corp.

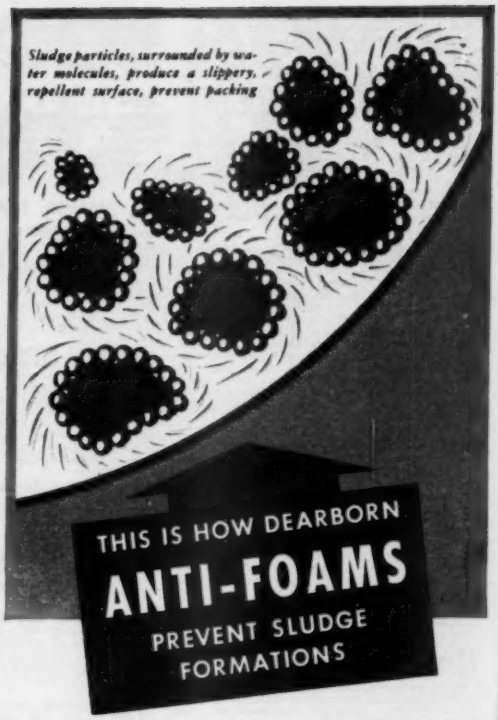
208 **Corrosion Treatment** — "Corrosion Protection of Steam and Condensate Return Systems" is a 4-pp folder covering amine treatment for inhibiting of boiler and condensate systems. This treatment is described as affording surface protection of the metal itself as well as raising the pH value of the condensate. Booklet gives specific case histories and typical economies obtained by power plants using this treatment. The Bird-Archer Co.

209 **Chemical Feed Systems — Single,** complete "packaged" units for feeding directly into boiler feed water lines are the subject of 4-pp Bulletin 4211. It covers various types of feeding, explains automatic control. Milton Roy Co.

210 **Modern pH and Chlorine Control**—This 100-pp booklet gives technical details of company's color comparators and equipment in water testing and control of boiler and industrial process water, also technical information on the meaning of pH control, electrometric and colorimetric methods of determining pH and also determining impurities in water; applications of water control in air conditioning; treating boiler feed water. W. A. Taylor & Co.

211 **Water Softeners — Bulletins WC-102** is a 36-pp presentation of recent developments in hot-process water softeners. Explains boiler plant troubles caused by various impurities in water, outlines 12 methods of treating water to eliminate these impurities, describes reasons for the popularity of the hot-process method and its advantages, and explains the chemistry of hot-process water softening. Graver Water Conditioning Co.


Sludge particles are permitted to settle into a compact mass, preventing water contact with metal surfaces
THIS IS HOW
SLUDGE FORMS
ON BOILER AND
TUBE SURFACES


Sludge particles, surrounded by water molecules, produce a slippery, repellent surface, prevent packing
THIS IS HOW DEARBORN
ANTI-FOAMS
PREVENT SLUDGE
FORMATIONS

DEARBORN POLYAMIDE ANTI-FOAMS KEEP SOLIDS IN SUSPENSION—PREVENT SLUDGE FORMATIONS

Dearborn Polyamide Anti-Foam No. 659 performs four important functions in boiler water treatment.

1. It makes it easier to maintain a fluid type sludge in boiler water. It prevents growth of the sludge crystals and does not permit them to become attached to the heating surfaces.
2. Anti-Foam No. 659 has protective colloid action which controls the precipitation of carbonate scale. It also prevents "after precipitation" where lime soda water is used for make-up.
3. As an Anti-Foam treatment, No. 659 reduces the number of small bubbles responsible for foaming conditions. Instead, it produces a relatively small number of large bubbles which break harmlessly on the surface.
4. Anti-Foam No. 659 prevents corrosion in feed lines, heaters and internal boiler surfaces caused by dissolved oxygen.

Consult your Dearborn representative for assistance in selecting the boiler water treatment best suited to your needs.

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THE LEADER IN WATER TREATMENT AND RUST PREVENTIVES

212 One-Minute Water Tests — Rapid, simple and accurate tests for determining water hardness are described in Bulletin 1RE50, 4 pp. Procedures, reagents, and equipment are pictured and described. Bulletin tells how tests may be used to determine water hardness, hardness due to calcium alone and hardness due to magnesium alone. Hall Laboratories, Inc.

213 Boiler Water Treatment — Bulletin 47, 8 pp, is on internal treatment of boiler water. Defines internal treatment and tells its advantages in softening, sludge conditioning, stabilization. Explains operation of company's system, including the chemicals used. National Aluminate Corp.

214 Ion Exchange Systems — "Amberlite Monobed Deionization" is a 12-pp miniature textbook covering the history, behavior, present performance, and potential uses of the Monobed ion exchange systems in water-conditioning, chemical processing and other industries. Reactions of various combinations of exchangers are explained in text and equations. Also discussed are operating costs, equipment costs, quality of product derived, rinse requirements and other properties as they apply to the complete or partial single-step removal of ionized solids. The Resinous Products Div., Rohm & Haas Co.

215 Pocket Book on Chemicals — Here's a handy little 28-pp manual covering chemical products used by the power engineer. Most of those listed are water treating chemicals, but there's also a brine treatment, a fuel oil sludge dispersant, a soot remover, and protective coating. Describes each product, tells what it does and how and where to use it. Includes a helpful reference chart suggesting the application of these products to several types of operations. Western Chemical Co.

BOILERS AND AUXILIARIES

216 Shop-Assembled Boiler — Eight-pp Bulletin G-72 introduces company's new integral furnace boiler. Describes and illustrates its economy, ease of installation and connection, flexibility, minimum space requirements, efficient combustion, fast steaming and ease of operation. The Babcock and Wilcox Co.

217 Dowtherm Vaporizer — Bulletin No. 48-2, describing manufacturer's Type "A" Dowtherm Vaporizer tells how this unit is designed to evaporate Dowtherm in such a way as to provide dependable operation at maximum temperatures, discussing its construction advantages in detail. The Wickes Boiler Co.

218 The Why of Dual Circulation Generators — The special advantages of company's dual circulation steam generator are presented clearly and factually in Bulletin B-30-11, 16 pp. Attractively illustrated with installation photos and sketches the text explains the principles of dual circulation. Tells the applications of this type of generator in both high make-up and low make-up plants. Foster Wheeler Corp.

219 Tube Expanders—Bulletin 380, 8 pp, covers manufacturer's line of tube expanders for maintenance of high pressure boiler tubes, superheaters, economizers, circulating tubes, steam generators other equipment. Thomas C. Wilson, Inc.

220 Bent Tube Boiler Data—This 20-pp booklet is filled with engineering drawings of recent installation of company's Class VL boilers, designed for adaptation to limited space conditions in plants having diverse steam requirements. Henry Vogt Machine Co.

221 Rotary Tube Cleaners — Bulletin R-105 presents air and water driven rotary tube cleaners and cleaner accessories. Illustrates several models and heads, discussing special features. Also includes data on motors, hose. Roto Div., Elliott Co.

222 Fuel Economizers — Both cast iron tube economizers and steel tube economizers are covered in detail in Catalog 169, 8 pp. Advantages of their diamond-shaped tubes and streamline flow of gas and soot blower steam are discussed. Green Fuel Economiser Co., Inc.

223 Water Tube Boilers—Eight-pp Bulletin SB24B describes and illustrates water cooled boilers with integral water cooled furnace. Explains design features that contribute to positive circulation and low maintenance, as well as construction advantages. Includes dimensions, photos of five installations. Erie City Iron Works.

224 Air Preheaters — Illustrated Bulletin A-11610, 8 pp, defines air preheat and explains its benefits in terms of increased efficiency and capacity and flame stability. Provides general description of company's preheater, discusses its application to boiler plants. Several installations are illustrated. The Air Preheater Corp.

VALVES, TRAPS, PIPING

225 Bonnet Valves—"Pressure-Seal" bonnet valves are described and illustrated in Form AD-1819. Includes sizes, dimensions, ratings and tests for gate, globe, angle and stop check valves as recommended for high pressure and high temperature service. Also explains operating advantages of the valves and tells how the pressure seal is made. Crane Co.

226 Valve Bulletin — Catalog Section 12-H describes various types of company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Edward Valves, Inc.

227 General Service Valves — Bulletin E-160, 16 pp, describes and illustrates the design and construction of company's quick-operating valves, explaining their application to blow-off service and on fire protection, chemical process, soot blower, water column blow-down, and other types of pipe line. Included are tables of dimensions, weights and list prices. Everlasting Valve Co.

228 Unions and Fittings — Twelve-pp Catalog 50 covers manufacturer's line of unions of all types, elbows, tees and fittings. It describes and illustrates special construction features and other advantages. E. M. Dart Mfg. Co.

229 Blow-Off Valves—Illustrated Bulletin B-433, 24 pp, describes blow-off valves for high-pressure boilers, and covers seatless, hard-seat and unit-tandem types, for working steam pressures from 400 to 2500 lb. Construction details and operating principles are illustrated by cutaway drawings. Dimensions and specifications included. Yarnall-Waring Co.

230 Welding Fittings and Flanges—Catalog and Engineering Data Book 211, a 262-pp manual, provides complete dimensional data, weights and prices on company's welding fittings and flanges. The engineering section contains practical information covering performance under varying conditions of temperature and pressure, location and materials processed. The technical section covers properties and rating of pipe, fittings and flanges, line expansion and flexibility, support and anchorage of piping and flow of fluids. Tube Turns, Inc.

231 Steam Traps and Temperature Controls—Here is a comprehensive catalog comprising many of company's bulletins on steam traps and related equipment, including an illustrated steam trap selection chart. Provides data on boiler steam traps, air eliminators, thermostatic steam traps and air vents, inverted bucket steam traps, temperature regulators and cooling controls, steam and water mixers, thermostats and strainers. Contains sizes, application data, prices. Sarco Co., Inc.

232 Steam, Air, Gasoline Traps — This 32-pp illustrated catalog, No. 250, describes five types of thermostatic steam traps for pressures to 225 lb; expansion steam traps for pressures to 250 lb; weight-operated traps for steam, air and gasoline service, pressures to 1500 lb; piston-operated steam traps for pressures to 650 lb, and also steam, air and gas separators. Includes capacity tables, installation diagrams. W. H. Nicholson & Co.

233 Handbook on Fittings and Flanges Catalog wf-1950, 88 pp, is packed with working information on seamless carbon steel welding fittings and forged steel flanges. In addition to presenting standard schedules with their specifications, list prices and sizes, book gives information on dimensional tolerances; American standard flange facings with dimensions; thread standards and threading practice; service pressure ratings, physical and chemical requirements for flanges, nuts and bolts; plus sizes and wall thicknesses of welding fittings in other metals. Grinnell Co., Inc.

234 How to Choose and Use Air Traps —Bulletin 262, 4 pp, describes manufacturer's complete line of air traps, covering their selection and installation for automatic drainage of moisture from compressed air intercoolers, aftercoolers, receivers, separators, and drip points. Prices included. Armstrong Machine Works.

235 Safety Valve Engineering Data—How company's safety valve works and its important operating advantages are explained and illustrated in Bulletin 707. Includes dimensions on flanged and welded inlet valve types, tables on superheat correction factor, capacities in pounds of saturated steam per hour. Manning, Maxwell & Moore, Inc.

236 Flanges for Severe Service — This 4-pp bulletin describes and illustrates a flange specially developed for services involving severe abrasion and corrosives, and for use in suction and discharge service. Photos and sketches illustrate the flange and its parts. Also covers a flexible rubber pipe for use with abrasive or corrosive material, and an acid- and corrosion-resistant duct. Goodall Rubber Co.

237 To Make Valves Accessible — This little folder describes a sprocket rim with chain guide. The rim adjusts to fit all valve wheels and makes them readily accessible. Prices given. Babbitt Steam Specialty Co.

INSTRUMENTS AND CONTROLS

238 Instrument and Control Panels — Bulletin 773, 8 pp, explains how company's panels are made and where they are used. All operations of fabrication are discussed and illustrated—layout, cutting, drilling, welding, fitting, painting, wiring. The Hays Corp.

239 Remote Reading Flow Meters—Data Book 702, 32 pp, fully illustrates and explains flow measurement problems and offers suggestions for their solution. Meter bodies, differential devices and reading instruments are fully described. Republic Flow Meters, Co.

240 What's Going On Inside?—Sight flow indicators for insertion into pipe lines carrying oil, steam, water, cooling liquids are described in Bulletin DD, 4 pp. Covers both cylinder and window types. Ernst Water Column & Gage Co.

241 Flow Meters—Bulletin 400-F2, 8 pp, features company's meter for measurement of steam, air, or gas flow in 1 or 1½ in. pipe lines, and designed for installation directly in the line being metered. Illustrated with photos of meter, sectional and dimensional drawings, the bulletin explains how meter operates, discusses its advantages. Builders-Providence, Inc.

242 Putting the Ratio Totalizer to Work—Twelve suggested applications of company's ratio totalizer in automatic control circuits are described and illustrated by diagram in 8-pp Bulletin 5450. This new device is a pneumatically operated control mechanism for combining input control pressures and spring forces to produce a single output control pressure. Applications in computing circuits include addition, subtraction, multiplication and division, averaging and reversal of loading pressure. Hagan Corp.

243 For Practical Men—That's the title of this 24-pp pocket-size booklet presenting insulation testing in simple language. Packed with maintenance hints, it explains electrical insulation, tells how it can be tested and what makes it go bad. It describes the Megger insulation tester and justifies its cost in terms of long run economy and prevention of shutdowns. James G. Biddle Co.

244 Air Locks—Bulletin S-31, 2 pp, describing company's air locks and trip master controls for holding regulating and control valves in position during failure of air supply, is illustrated with photos, diagrams and line drawings. The Swartwout Co.

245 Flow Tube — Catalog 80, 4 pp, presents engineering data on a new primary element for measuring, regulating

(Continued on page 116)

The MONTANA POWER COMPANY

buys VULCAN

for this OUTDOOR PLANT

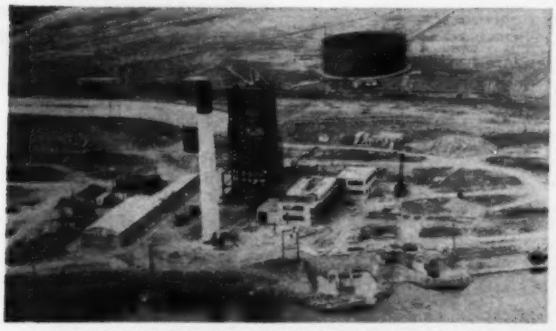
Ambient temperatures ranging from −40 to 100 degrees F. will mean many operating problems at the new Frank Bird Steam-Electric Generating Plant. Soot blowing, however, will not be one of these problems. Vulcan automatics will clean the boiler effectively, no matter what the weather.

Driven by electric motors and blowing with steam, the fourteen Vulcans will need no anti-freeze devices—no special provision for lubrication, winter or summer.

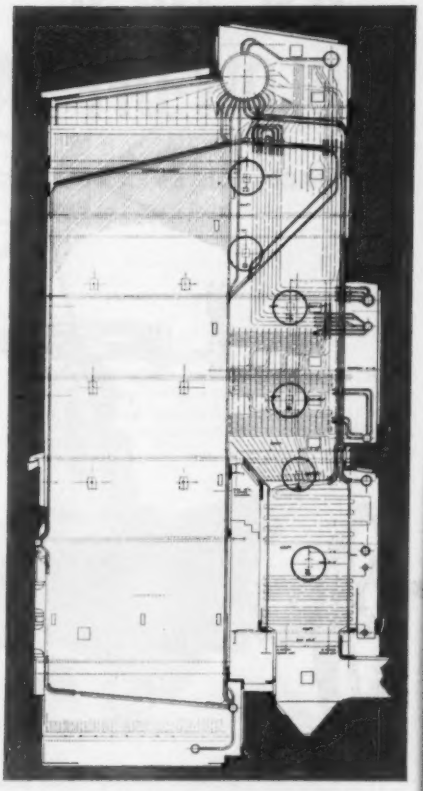
With all blowers operated by push buttons on the boiler panel, operators will not need to step outside the control room to keep the boiler and air-heater passes free from soot. They will have no reason to "forget" to blow soot in bad weather. They will have more time for other duties.

Indoors or outdoors, you can depend on Vulcan for effective boiler cleaning over a long service life, with maintenance costs held to a minimum.

VULCAN SOOT BLOWER DIVISION
CONTINENTAL FOUNDRY & MACHINE COMPANY
DU BOIS, PENNSYLVANIA



The FRANK BIRD STEAM-ELECTRIC GENERATING PLANT at BILLINGS . . .



Rated at 675,000 pounds per hour, this Foster Wheeler boiler will deliver steam from the superheater at 920 psi and 905 degrees FTT. Firing will be with Bunker "C" oil and natural gas.

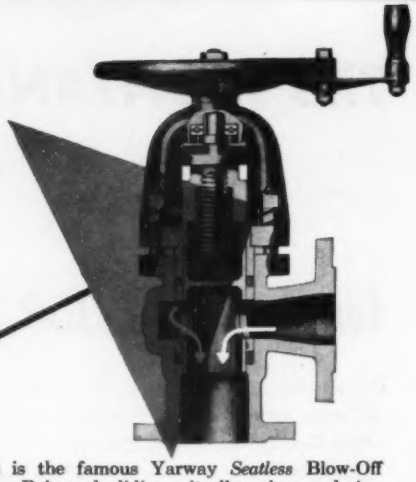
The Vulcan installation will include twelve long retractable soot blowers, plus two controls for the special air-heater blowers. All will blow with steam and be driven by electric motors. An individual push button control for each blower is provided at the boiler operating panel.

Consulting Engineers: Ebasco Services, Incorporated, New York City.

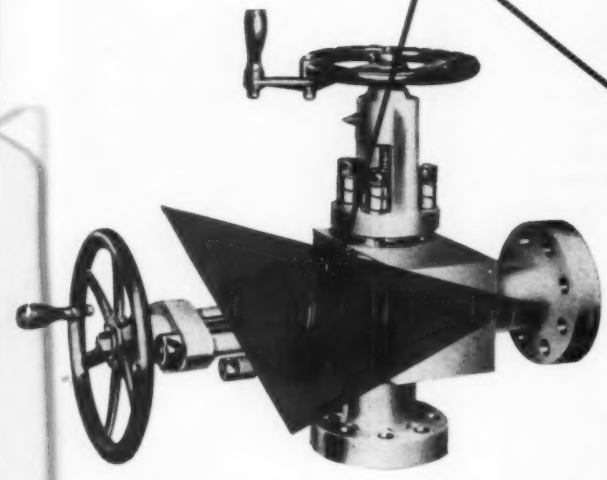
VULCAN *Automatic Soot* **BLOWERS**

OVER 15,000 BOILER PLANTS USE THESE BLOW-OFF VALVES

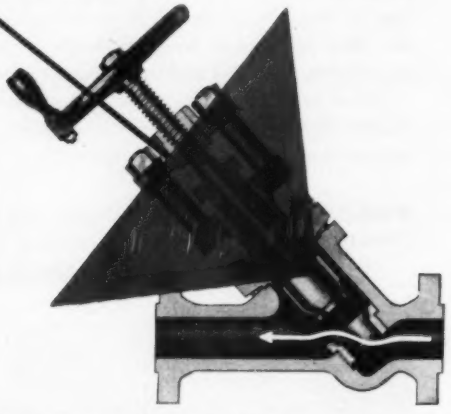
MADE FOR EVERY PRESSURE



This is the famous Yarway *Seatless* Blow-Off Valve. Balanced, sliding, nitralloy plunger design eliminates seat—a common source of wear, clogging and leaking. Type B (above) for pressures 50 to 400 psi, angle or straightway, single or tandem. Other types available for higher pressures. Complete description and specifications in Bulletin B-424 for pressures to 400 psi, or Bulletin B-433 for higher pressures.



The Unit Tandem—Yarway's finest blow-off valve for high pressure service. Combines a Hard Seat Valve (for blowing) and a Seatless Valve (for sealing) in a one-piece forged-steel body, flanged or socket welding ends. Also available combining two hard-seat valves. For pressures to 2500 psi. See Bulletin B-433.



This is Yarway's Stellite-Seat Valve for pressures to 2500 psi. Shown here in open position. Disc and seat ring are stellite-faced and carefully mated for tight seating, long life and hard wear. Angle or straightway, single or tandem combinations (hard seat—hard seat or hard seat—seatless) available. Complete specifications and description in Yarway Bulletin B-433.

YARNALL-WARING COMPANY • 114 Mermaid Avenue, Philadelphia 18, Pa.

BRANCH OFFICES IN PRINCIPAL CITIES

STEAM PLANT EQUIPMENT

LETTERS TO THE EDITORS

CONTINUOUS BLOWDOWN SYSTEM

I HAVE READ with interest the description of Lahm's continuous blowdown system as set forth in January 1951 issue, page 88. As described, this system is a simple scheme for handling continuous boiler blowdown, but there are one or two points in question which I would like to direct to Mr. Lahm.

It is the writer's understanding that continuous blowoff would be extracted from the boiler drum immediately below the low water level and would pass through a 3/4 in. valve into the settling chamber. As illustrated, it would appear that retention time and velocity through the settling chamber would preclude the possibility of suspended matter settling. Agitation in the settling chamber would be aggravated should there be sufficient pressure loss across the 3/4 in. valve to produce a flashing condition.

Continuous blowoff control is accomplished through one or possibly a combination of the stainless steel orifices and apparently discharge is directed to the sewer. If this is the case, a mixture of steam and water produced by the drop in pressure across the control orifices will be introduced to a sewer line. I have been under the impression that most municipal authorities prohibit such a practice and as a matter of fact, limit the maximum temperature for boiler water blowoff to the sewer. In other words, is it not true that most municipalities would prohibit the use of such a system?

In order to overcome these objections and recover heat from the continuous blowdown at the same time, we have found the simplest and most effective system to be a combination flash tank-heat exchanger arrangement. For low pressure boilers and moderate continuous blowoff requirements the system may be further simplified by omission of the flash tank and utilization of a heat exchanger placed in the continuous blowoff line preceding an adjustable control valve.

M. C. McKEOWN

BASIC POWER PLANT FIGURING

WHEN WE ASKED, in the January issue, for comments from readers on the Basic Power Plant Figuring articles by William H. Engelman, we knew we would get a tremendous response. And we did. We already had scores of comments from readers, sent in at various times as the articles were published beginning in February 1949.

Here is just a sampling of the comments received on the return postal card from the January issue. Because we haven't had time to ask each reader personally for permission to publish his comment, we give only his initials and title.

* * *

Just to let you know how much I enjoyed using Mr. Engelman's tables and calculations. They are very helpful and I'd like to see more of them.

O. F. F.
Project Engineer

* * *

I have thoroughly enjoyed Mr. Engelman's articles on Basic Power Plant Figuring.

R. V. K.
Power Engineer

* * *

I think Mr. Engelman's Basic Power Plant Figuring articles are GREAT. I would like to be notified as soon as this complete series is printed in book form. I will need several copies.

W. S. A.
Results Engineer

* * *

Mr. Engelman's articles are very practical. I've been using them to instruct new men to handle efficiency reports and plant calculations. Well written and simple enough for even our ashmen. I appreciate each article and have clipped them for my own notebook.

H. M. L.
Results Engineer

* * *

Power plant calculations of great interest—would like to see them in book form.

T. F. F.
Mechanical Engineer

* * *

Tell Engelman to keep them coming.

W. F. A.
Watch Engineer

* * *

I think Basic Power Plant Figuring is best part of your magazine. Looking forward to its continuation. Would like to see something on hydraulics.

N. L.
Chief Engineer

* * *

I really enjoy Mr. Engelman's articles and think they should be continued.

F. F. P.
Engineer

* * *

Mr. Engelman's articles have been "tops" with our power plant personnel. Glad to hear they are to be issued in book form. Send me one as soon as published.

A. V. E.
Supt. of Power

* * *

Articles by Mr. Engelman are of great interest to me. Please continue to publish same. Also publish articles by Mr. Engelman in book form.

T. B.
Chief Operating Engr.

* * *

Mr. Engelman's articles are wonderful. Keep up the good work. When in book form send one c.o.d.

J. A. F.
Engineer

* * *

Please continue Mr. Engelman's very valuable articles on Basic Power Plant Figuring.

J. E. G.
Chief Engr., Power House

* * *

Please do not discontinue Basic Power Plant Figuring articles. I find them very helpful. How about some articles on ammonia refrigeration?

W. H. N.
Chief Engineer

* * *

I believe the articles on Basic Power Plant Figuring by Engelman are well written, clear, practical, concise and very helpful. I have saved each article for our reference file.

H. K. B.
Director of Engineering

* * *

How can I refresh my memory without Engelman's fine articles on Basic Power Plant Figuring?

G. A. H.
Building Supt.

* * *

Best set of short cuts and most clearly explained theories I have seen.

C. M. J.
Plant Engineer

* * *

Give us a lot of articles on Basic Power Plant Figuring. They are very timely. If and when in book form please advise me.

J. W. B.
Chief Engineer

* * *

Engelman's Basic Power Plant Figuring excellent. Source of review and new improvisations of design, fresh treatment for both experienced and inexperienced. If possible, could I have tear sheets of all articles?

A. S. C., Chief Designer

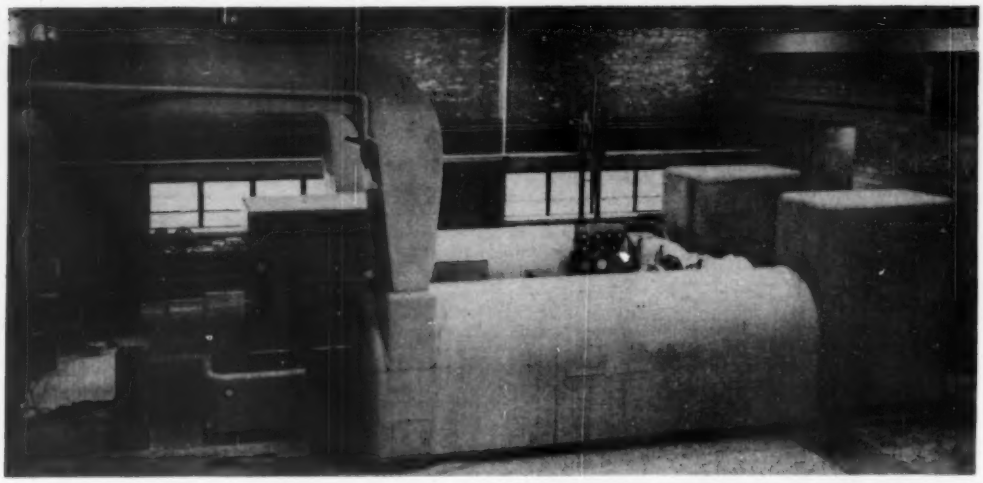


Fig. 1. Interior view of Edward M. Graham Station showing the first 5000-kw regenerative gas turbine unit. Turbine, combustors and compressors between regenerators and intercoolers. Cubical casing at left houses generator with top-mounted generator air cooler

First U.S. All-Gas-Turbine Power Plant — The Edward M. Graham Station

WHEN THE Bangor Hydro-Electric Co. of Bangor, Maine, completed and put into operation, on October 30, 1950, its new 5000-kw regenerative gas turbine generating unit, it reached two new benchmarks on the path of progress of the gas turbine in the United States. One of these marks the fact that this is the first installation of a new regenerative type of gas-turbine unit to go into central station service solely for power generation. The other marks the fact that this installation is the first one planned as an all-gas-turbine power station, its connections with other plants being only electrical circuits through which it delivers its power into the company's transmission system.

The plant is the Edward M. Graham Station shown in Fig. 5, located at Veazie, on the Penobscot River, just outside Bangor, Maine. It was named for Edward M. Graham, president of the Bangor Hydro-Electric Co., who placed it in service on October 30. The station was engineered by Charles T. Main, Inc., of Boston.

General Design of Station

Provisions are made in the design of the station for installation of a second duplicate gas turbine generating unit, which has already been placed on order with the manufacturer. The first of these regenerative-type gas turbine units was selected[1] to provide standby and peak back-up for the hydro stations on the system in conjunction with its Diesel[2] capacity. Although rated at 5000 kw, the new Bangor unit is equipped with a 6000-kw, 0.8-pf electric generator, with enclosed top-mounted air cooler, to take advantage of the overload capacity inherent in a gas turbine in regions of low ambient temperature.

This gas turbine operates on No. 6-Bunker C-oil. Fuel storage tanks and centrifuges for cleaning the oil, also necessary heating and pumping facilities, have been provided for the two ultimate generating units, as in Fig. 4. Separate storage for light oil fuel also has been provided, for starting the unit before transfer to Bunker C and for purging the fuel lines before stopping.

The gas turbine of this unit is of the compound cycle design, with a high-pressure gas turbine and a low-pressure gas turbine on separate shafts, in the same casing, as shown in Figs. 4 and 6.

A water-cooled intercooler is placed between the first and second stages of air compression. Circulating water for the intercooler and for the generator air cooler and lubricating oil cooler is obtained from the Penobscot River, on the bank of which the station is built, Fig. 5. A regenerator, heated by the turbine exhaust gas, is located between the second stage of compression and the six combustion chambers to preheat the combustion air and reduce fuel requirements. Intercooler and regenerator are divided into 2 sections.

Operating Cycle

The operating cycle, Fig. 2, is this: Assuming the unit to be operating at rated load, air from outside the building is led through an underfloor duct to the inlet of the 1-p air compressor. This compressor compresses the air to approximately 42 psia absolute and 316 F. From the 1-p compressor discharge, the air

[1] While the new Bangor unit is the first of this new regenerative design to be installed in a central station solely for power generation, it is numerically the third stationary gas turbine generating unit to be so installed. The first was placed in operation at the Belle Isle (formerly Huey) Station of the Oklahoma Gas & Electric Co. on July 28, 1949. (See *Power Generation*, December 1949.) That unit is rated at 3500 kw and has operated over 10,000 hr on natural gas at an average load of approximately 120 per cent. A second gas turbine generating unit, a duplicate of the Belle Isle unit, except that it operates on Bunker C oil, was placed in operation by the Central Maine Power Co. on August 30, 1950, at Farmingdale, Maine (see PE, June 1950). Both these 3500-kw plants are the simple open-cycle type and are of the same design as the gas-turbine-electric locomotive that has been operating since July 29, 1949, on the lines of the Union Pacific Railroad. (See PE News Reel, February 1951.) The new Bangor regenerative unit is designed for higher operating efficiency for power generation than the simple open-cycle units referred to above.

[2] See: Diesels in a Hydro System, POWER ENGINEERING, July 1950. See also Regenerative Gas Turbine Efficiently Supplements Hydro, by Paul F. Kruse, Chief Engineer, Bangor Hydro-Electric Co., *Electrical World*, January 1, 1951.

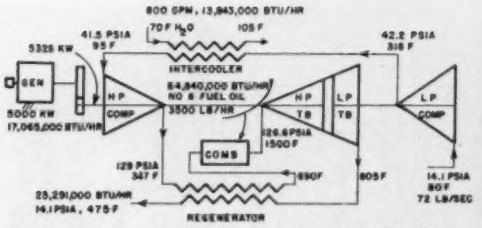


Fig. 2. Cycle and partial heat balance diagram for 5000-kw gas turbine at 80 F and 1000 ft above sea level, burning No. 6 fuel oil

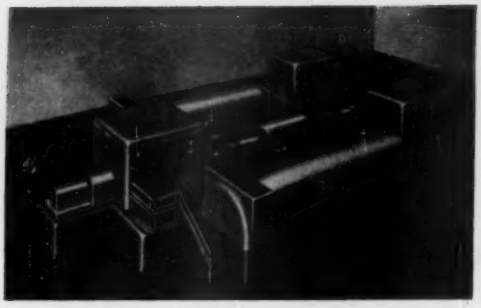


Fig. 3. Artist's design perspective of 5000-kw gas turbine generator set, to show relative location of elements all on one level

flows through ducts to each section of the divided intercooler, where its temperature is reduced to 95 F, still at approximately 42 psia. From the intercoolers, the air flows through ducts below the unit to the intake of the h-p compressor which raises its pressure to 128.6 psia and 347 F. This air flows then through the regenerator, where its temperature is further raised to 690 F; it then enters the combustors, where 3500 lb per hr of No. 6 fuel oil are burned, raising the temperature of the air and combustion gases to 1500 F at 128.6 psia.

The combustion gases enter the h-p turbine and expand through h-p and 1-p turbines. The h-p turbine drives the h-p compressor and, through reduction gears, the generator and exciter at constant speed. The 1-p turbine drives the 1-p compressor at variable speed with variable load. The exhaust from the 1-p turbine passes through the regenerator, heating the combustion air flowing to the combustors. In the regenerator, the temperature of the exhaust gases is reduced to 475 F at atmospheric pressure and the gas exhausts through the overhead ducts shown in Fig. 1.

The complete 5000-kw gas turbine power plant and control was manufactured by General Electric Co.—a completely coordinated design supplied as a package unit, to require a small and relatively inexpensive foundation. It is expected that eventually it can be made fully automatic, with remote supervision and control. Estimated cost is under $200 per kw installed.

The power plant building and permanent structures are simple and less expensive than those of a steam plant. Water requirement for cooling purposes is only from 1/4 to 1/6 that required for condensing in a comparable steam plant. On January 1 the price of Bunker C oil was about two-thirds that of premium Diesel fuel in Bangor, Maine.

This gas turbine unit may be placed on the line from cold in 15 min.—important when the plant operates at light load factor on the peak of the load. It is expected to require much less attendance and lower maintenance charges than

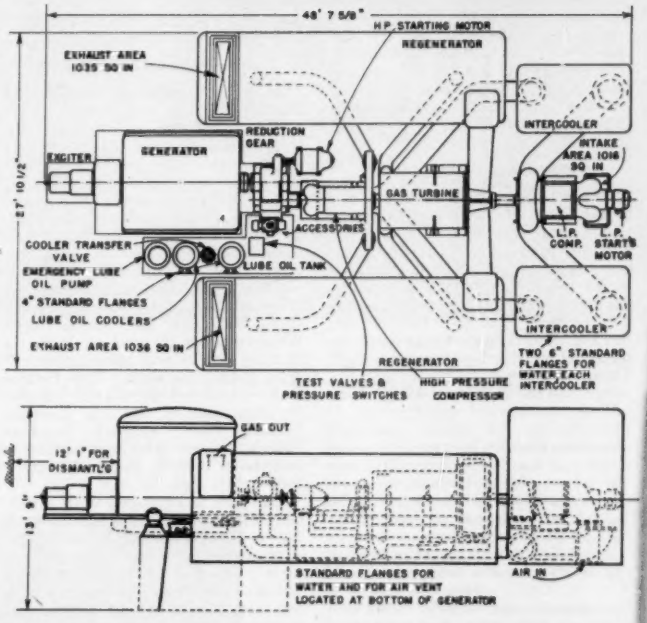


Fig. 4. Installation outline of main machinery, piping and heat exchanger components

Fig. 5. General air view of new Edward M. Graham Station. Fuel-oil storage tank at extreme left; circulating water pump house, at center right, on bank of Penobscot River; switchyards in background

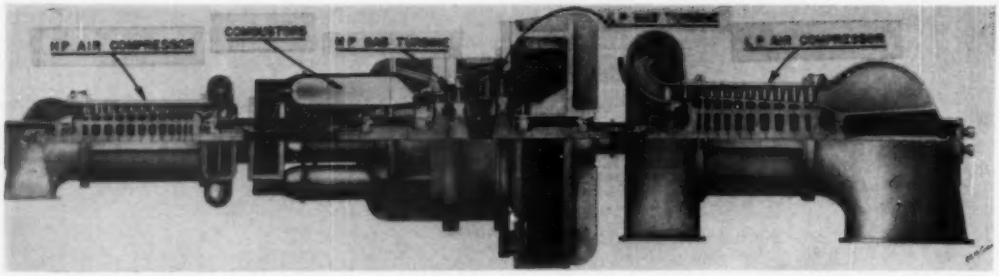


Fig. 6. Phantom cross-section of 5000-kw regenerative compound gas turbine shows how high-pressure and low-pressure elements are mounted with shafts on same center line; high-pressure turbine exhausting direct to low-pressure turbine with no piping between them

comparable plants of other types.

Details of construction[2] of the unit are shown in Figs. 3, 4 and 5. One feature is that all piping and ducts between the elements are below the unit, except exhaust ducts. This plant incorporates no piping at turbine inlet temperature.

Details of Gas Turbine Unit

The gas turbine unit consists of a 2-stage high-pressure and a 1-stage low-pressure section, Fig. 6. The h-p gas turbine and the h-p axial type air compressor are mounted on the h-p shaft with six combustors arranged around the inlet of the h-p turbine. The 1-p turbine and the 1-p axial type air compressor are mounted on the 1-p pressure shaft. These two separate shafts are arranged on the same center line. One unique feature of construction is that the six combustion chambers discharge directly into the first stage nozzles of the h-p turbine. The second stage of the turbine exhausts directly into the single stage of the 1-p turbine without any piping or duct work between them.

A total of only 3 stages is used in the turbine for the pressure ratio of 9 to 1. This permits the use of a high energy, particularly in the first stage, so that there is a substantial temperature drop from the turbine inlet temperature of 1500 to the buckets of the first stage, which operates at approximately 1300 F. The turbine is designed for continuous operation at 1500 F turbine inlet temperature and is expected to produce a kilowatt hour at the generator terminals for 12,900 Btu at rated conditions, based on 18,400 Btu per lb. Bunker C fuel oil.

The h-p turbine operates at approximately 8700 rpm and drives the 3600-rpm electric generator and its connected exciter through reduction gears. All essential operating auxiliaries are shaft driven from an accessory drive take-off mounted on this reduction gear.

The 1-p turbine normally operates at approximately 7700 rpm but at part load will operate at lower speeds to benefit cycle efficiency.

Turbine Materials and Cooling

Both the 2-stage h-p turbine and the single-stage 1-p turbine have overhung rotors permitting the closely stacked construction.

The main body of both turbine stator and rotor operate at relatively low temperatures and are made of low alloy carbon steel with a welded-on rim of high-temperature austenitic material, while a small region in the hot gas path, thermally isolated from the main frame, is made of austenitic material to withstand the high gas temperatures. Water cooling is used on both the turbine stators and rotors, about 30 gpm being required. The turbine stator is cooled by water passages in rings and in the low pressure turbine rotor support brackets. Rotors are cooled by heat transfer to stationary cooling pads adjacent to the turbine wheels.

The unit is equipped with a self-contained lubricating system, including a main lubricating oil pump, gear-driven from the accessory drive, an a-c and d-c motor-driven emergency centrifugal oil pump, two coolers and the necessary supply and storage tanks.

The combustors are interconnected with flame tubes to ignite all burners as soon as one is ignited, which is done by means of two spark plugs and ignition transformers. Air-atomizing fuel nozzles are used for oil firing. The turbine is started on Diesel oil and the heavier fuel oil is admitted only after the pipes and Bunker C tank are heated. A variable-stroke fuel pump is gear driven from the accessory drive.

Control of Unit

Primary control of this unit is by regulation of the fuel flow rate. This is done by a fuel regulator and electro-hydraulic governor. This governs speed, cuts back on fuel flow if turbine temperature rises above safe level; limits rate of change of turbine temperature; provides control of fuel during starting and at low speed; and is equipped with adjustable constant fuel stop to maintain constant load on the unit. The control system also includes compressor guide vane adjustment. Overspeed protection by overspeed governors is entirely independent of the normal governor.

Cooling water consumption of the various elements is expected to be:—Intercoolers, 800 gpm; generator air coolers, 170 gpm; oil coolers, 100 gpm; turbine cooling system, 30 gpm; total 1100 gpm.

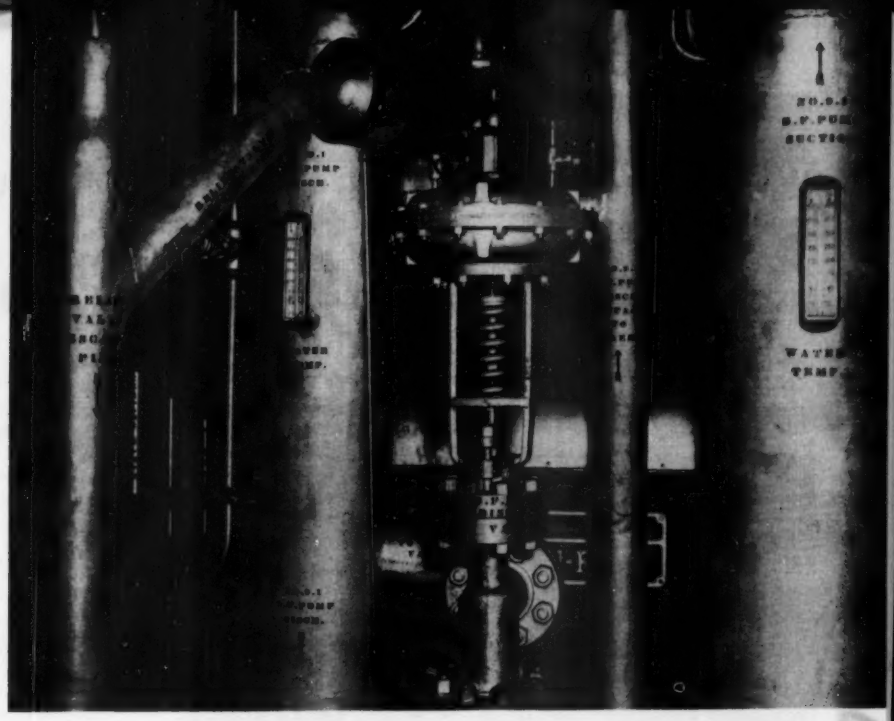
Starting power for the h-p turbine is provided by a 100-hp 3600-rpm motor connected through an over-running clutch to an auxiliary drive shaft on the main reduction gear. This motor supplies starting torque to 5650 rpm of the 8700 rpm shaft, at which speed it is disconnected by the over-running clutch and the gas turbine accelerates to full speed with no further assistance. Also, to materially reduce the starting time, a 40-hp motor is direct-connected to an extension of the 1-p compressor shaft through another over-running clutch. A turning gear is also provided for initial turning of the h-p turbine shaft at 1 rpm. This gear is to assist in breakaway torque and to establish bearing oil film.

Intercooler and Regenerator Details

The intercoolers are series counterflow, designed for 90 per cent effectiveness; each has two removable cores of spiral-wound fins soldered to 1-in. O.D. admiralty metal tubing. Tube sheets are of Muntz metal and the cores are mounted in a pressure casing with 22 in. inlet and 20 in. outlet air pipe connections.

In the regenerator, the high-pressure air flows outside the tubes in the cylindrical shell space while the exhaust gas at atmospheric pressure flows inside the tubes. The regenerator is designed for 75 per cent effectiveness, and 1-in. diameter tubes are employed to permit easy cleaning and low cost. Each of the two regenerator units contains 2500 1-in. tubes 20 ft long, total surface of 26,200 sq ft. Maximum exhaust turbine gas temperature is 870 F, therefore the entire regenerator is constructed of carbon steel. The pedestal opposite the gas inlet slides to care for thermal expansion.

[2] See: 5000-kw Gas Turbine for Power Generation by Allan Howard and Chapman J. Walker, General Electric Co., Paper No. 48-A-83, presented before the 1948 annual meeting of the ASME in New York. This paper was presented shortly after the machine was ordered in October 1948.



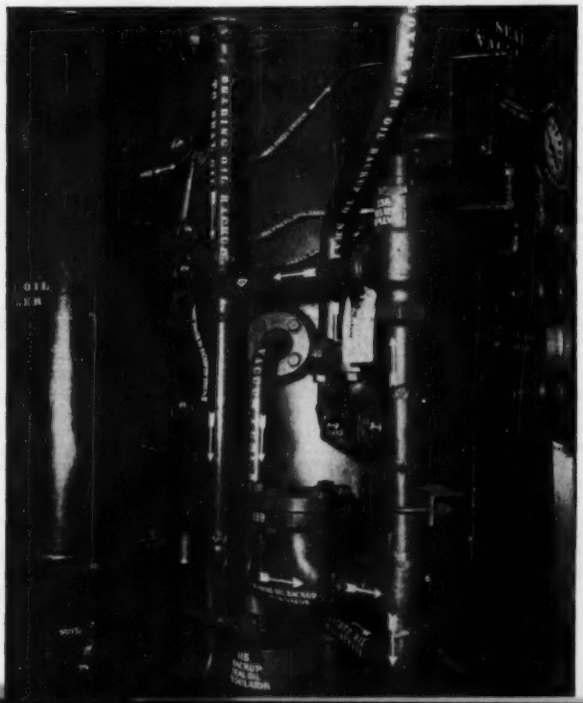
Good Pipe Labeling Aids Operation at Edgar Station

One outstanding feature of the new reheat turbine-generator installation at the famous Edgar Station of Boston Edison Co. is the complete and effective identification system for all piping, valves and auxiliaries. These photographs show the way in which legends on every item tell what the equipment is, where the piping leads and what it is carrying, and also what the valves are for.

No piping color identifying code is used. Instead, all piping and equipment insulation is painted the same light grey and the legends are sharply stenciled right on the insulation in black. For uninsulated equipment, white lettering is used.

This system of marking is used throughout the new installation. This is a 65,000-kw. (81,250 kw capability) reheat turbine generator, supplied by a single steam generating unit with steam at 1450 psi, 1000 F, with reheat to 1000 F. Is was installed in 1949.

Edgar Station was the first to install, in 1925, a commercially practicable 1250-psi, 725-F boiler, with reheat to 725 F at 375 psi. Since that time, the station has used reheat in all subsequent units. Thus it was a complete reheat station right from the beginning.



What the Power Engineer Needs to Know About

Burning Gas in Modern

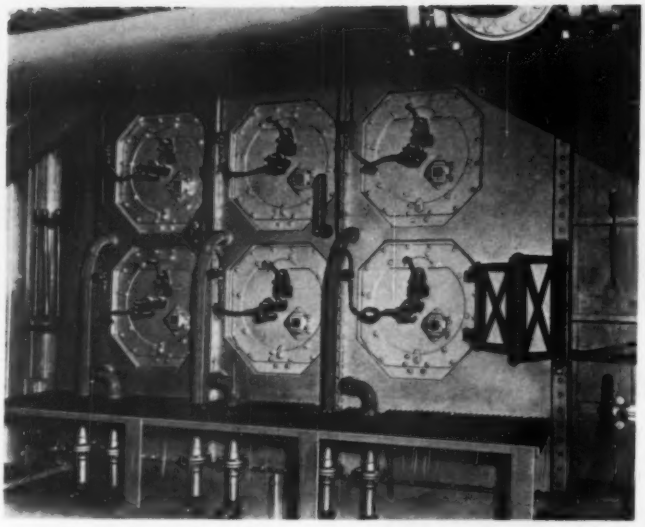


Fig. 1. Gas burners installed to fire a typical industrial steam generating unit

IT IS NOW POSSIBLE for many power engineers to obtain gas for boiler fuel in parts of the country where it has not hitherto been available. This has been brought about by the great expansion in the nation's natural gas pipeline systems during the past few years. In some cases, the natural gas is mixed with manufactured gas, in others it is not. In some cases, the gas supply is available only during a portion of the year; in others, the year around.

In any event, utility and industrial power plant managements, learning that gas for boiler fuel will be available part or full time, call on their power engineers to consider what can be done to burn it. "No ash; clean, simple to handle; no storage problems—ought to be a cheap fuel," they say.

Correct—in a great many cases. The local gas utility will give engineers and management every cooperation in utilizing as much gas as is available, to reduce steam costs. In fact, under many conditions, the engineers of the gas utility may be the only ones able to analyze correctly all the factors involved. These engineers, together with the engineers of gas burner manufacturers, have most of the technical data necessary. Also, competent consulting engineers are available, who know the technique of gas burning and can help analyze the economics of it. In short, there is a great deal of information available on how to analyze the benefits of burning the gas available.

It is not the purpose of this article to show how and why it may pay a given plant to burn gas. Rather, this article assumes that the engineer wants and needs to know about the physical details of burning it in his particular plant. These must be taken into account in determining whether it will pay to burn it.

Furthermore, this article proposes to discuss gas-burning fundamentals in what are commonly considered power boilers, of the types shown in Fig. 3. Many types of "package" boilers are especially designed for firing with oil and gas and many of them are available in capacities up to 300 and even 500 hp. However, such package units are designed as complete assemblies to burn gas or oil, with all items coordinated by each designer and manufacturer especially for their particular make of steam generator. For obvious reasons, they are not discussed here but will form the subject of another article.

Converting Boilers to Gas Firing

In general, unless there is some unusual condition, it is not difficult to adapt modern boilers, now fired by coal or oil, to burn gas.

The common situation is conversion of existing boilers to burn gas, retaining the existing fuel-burning equipment as supplementary during the gas-burning season and returning to it if the gas supply has to be shut off. In many parts of the country, boiler plants have already been designed for coal and oil burning. Such plants can easily add gas, since furnaces well designed for coal and oil are satisfactory for gas or can be made so without too much expense. Some of the newer plants, both utility and industrial, have been designed to burn any of the three fuels, an example being the boiler of Fig. 3C.

It must be emphasized, however, that burning gas differs in some important respects from burning oil or pulverized coal. For one thing, gas usually burns with a non-luminous flame, hence the amount of radiation to heat absorbing surfaces is different. For another thing, the ideal furnace would be no larger than needed to enclose the gas flame, but the actual furnace shape must be somewhat different. Because of cleaner combustion, the heat transfer through boiler and water wall tubes is higher, hence interior tube surfaces must be really clean — that is, feedwater treatment must be right.

Now that many modern boilers

Power Boilers

By JOHN H. D. BLANKE

Many plants becoming more interested in burning gas, as increased supplies are made available by expanded gas pipe line systems . . . Industrial fuel supply may be available year round, or only in summer when domestic load is off . . . When conditions are right, gas fuel may provide lowest cost steam . . . Hence, many power plants will adapt existing boilers and furnaces to use as much gas as they can get . . . All types of boilers can be arranged to burn gas . . . Furnace volume and heat release for gas . . . Types of burners used . . . Automatic combustion control . . . Safety in lighting-off and operating . . . Flame failure safeguards and combustion safeguards . . . How to install and operate pilots . . . Cost of burning gas

are designed to have completely water-cooled furnaces, problems of radiation, flame temperatures and the like in these boilers must be taken into account.

Gas-Fired Power Boilers

Gas burners are firing power boilers ranging all the way up to 600,000 lb per hr of steam or even higher. Typical boiler installations for gas firing are shown in Fig. 3.

The engineer who designs gas burner installations must determine accurately the maximum safe heat input to the boiler—if troubles in the form of blistered and warped tubes are to be avoided. There is but little standardization to aid the engineer in the proper selection of gas burning equipment for boilers larger than the domestic and commercial heating units.

Three general classes of power boilers are available for gas firing; the brickset, the firebox and the water-wall furnace boiler.

Brickset boilers ordinarily offer no serious problems in the conversion to gas fuel. Most designs of burners can be installed without too many changes in the combustion chamber. The refractory, when hot, aids in the combustion of the gas-air mixture. And if ample flame travel is possible, there is no difficulty in completing combustion before the cold surfaces of the boiler are reached.

Brickset boilers include the horizontal return tubular, the straight-tube of either horizontal or vertical type, the bent-tube of the three drum or four-drum type, and the cross-tube boiler.

Usually the brickset boilers have walls 18 to 27 in. thick, either insulated or not insulated. Some of these boilers are fitted with air-cooled sidewalls through which all or part of the air for combustion is passed before it enters the fuel bed.

Larger boilers are often equipped with water-cooled walls. These may be covered with refractory, to reduce maintenance and slag when burning coal; or the tubes may be entirely or partially exposed.

The firebox class of boilers, internally fired, is found commonly in smaller sizes, generally on low-pressure work. Included in this class are Scotch marine boilers, locomotive boilers, and both up and down draft types of two-pass boilers. Such boilers have mechanical and combustion problems not found in brickset boiler designs, when considering installation of gas conversion burners.

A gas burner is fundamentally a mechanical device for producing a good mixture of fuel gas and air. There are two general types of gas burners

1 — Nozzle-Mixing
2 — Pre-Mixing

The first type may be again divided into multi-tube and register types. The various types are shown in Figs. 5 to 16.

Characteristics of Burners

All multi-tube burners have adjustable louvers or doors for controlling supply of air to the burners. Sometimes the louvers are fixed in position to give satisfactory operation, the air flow being controlled by the boiler dampers. The louvers then serve merely to shut off air when burner is out of service.

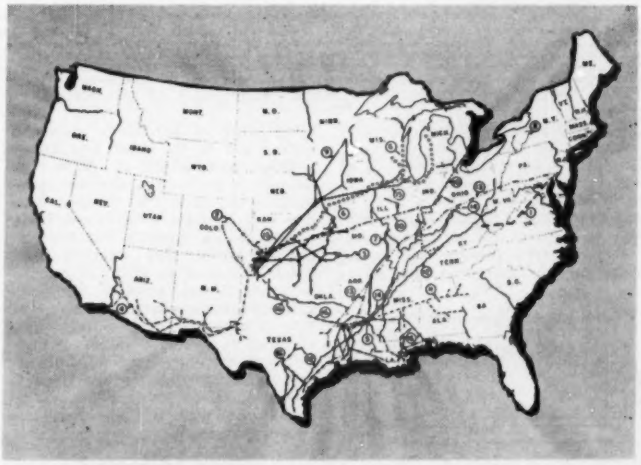


Fig. 2. Location of major interstate natural gas pipe line systems as of 1949 (From *Gas Facts* 1949, By AGA)

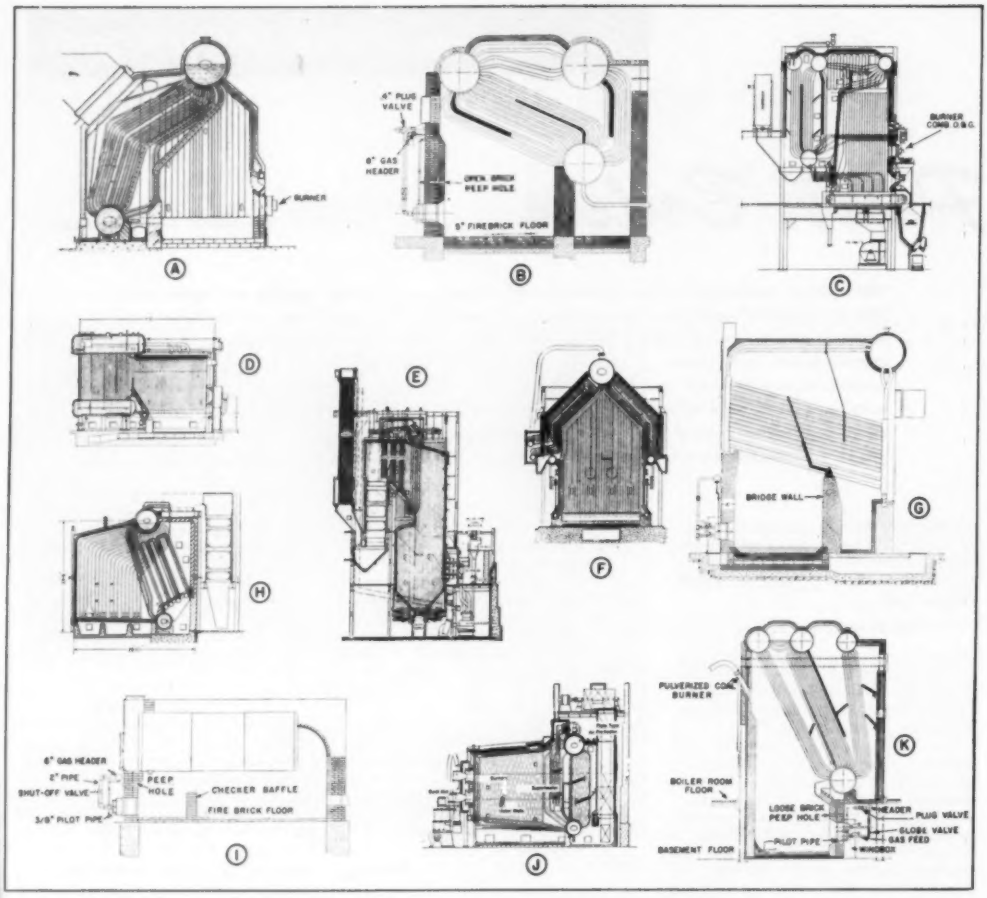


Fig. 3. Diagrammatic cross-sections showing various types of power plant boilers that have been fired with gas

A—Two-drum, vertical-unit, 60,000-lb-per-hr boiler. B—Low-head vertical bent-tube 400 hp boiler. C—Modern 4-drum vertical boiler, 85,000 lb per hr, with water-cooled furnace, equipped for firing either with coal by spreader stoker or with oil or gas by combination burners. D—Two-drum Type RO industrial boiler, with complete water-cooled furnace, burning natural gas. E—Large radiant-type boiler for central-station service, capacities up to and even exceeding 1,000,000-lb per hr for firing by coal, oil or gas. May also be built for tangential corner firing. F—A-type boiler, 77,500 lb per hour. G—Cross-drum, straight-tube header type boiler; same type may also have one or two longitudinal drums. H—Inclined 2-drum integral furnace boiler. I—Horizontal return tubular boiler. J—Two-drum integral-furnace boiler for combination firing. K—Vertical, bent-tube, 4-drum boiler

Multi-tube burners are essentially low-pressure burners, operating best at gas pressures between 2 oz and 1 psi. Most of them operate on natural draft; a maximum draft of 0.25 to 0.30 in. H_2O should be available to develop full boiler capacity.

Register type burners are essentially high-pressure burners, operating best at pressures above 8 ounces per sq in. Draft loss across register-type burners should be high enough to produce a definite spinning action in the air stream. This can best be done with forced draft.

Pre-mixing burners mix the gas and air before they enter the furnace. They produce short, high-temperature flames, suitable for small combustion chambers. Their operation does not depend entirely upon stack draft.

There are many types of combination burners available for burning gas and oil, or pulverized coal, oil and gas and some of these are shown diagrammatically.

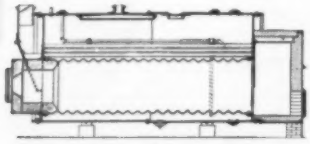


Fig. 3L. No, we didn't forget this one—the well-known and widely-used Scotch marine type boiler, frequently fired with gas

General Considerations

Burners are installed in general as shown in Figs. 3 to 16. Details for installation of a particular type of burner are usually furnished by its manufacturer.

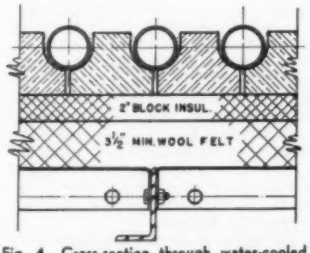


Fig. 4. Cross-section through water-cooled wall of furnace designed specially for gas firing. For gas, one manufacturer protects tubes thus by extending ship-lap tile nearly to inside face of tubes. For coal or oil, tile need extend only to tube center-line

On power boilers, it is general practice to light off gas burners manually, to use pilot burners to light the main burners, to operate in many cases with forced draft and often with both forced and induced draft fans, to install automatic combustion controls, combustion safeguards, (flame failure controls) and to require highest standards of equipment, design and operation. In many plants, a multiplicity of old boilers has been replaced or is being replaced by a very few larger modern steam generating units, hence safety and reliability of service from each modern unit are paramount. Here are some of the things the power engineer needs to know about burning gas in modern power boilers.

Proper selection of burners for a given boiler is not merely the simple matter of installing sufficient gas burning capacity to develop the desired rating. The load characteristics of the plant exert an important influence. Special attention must be given to maximum and minimum loads, also intermediate loads. Shape of combustion chamber is another important factor. Arrangement of burners, turn-down ratio of burners, furnace wall construction and many other factors must be considered. These are discussed in detail by A. D. Frydendall in Reference 1 (at the end of this article). In most cases, the consulting engineer and the gas utility engineer can advise the power engineer best on the type of burner to fit his particular conditions.

Piping Systems for Gas

Natural gas flows through pipelines for hundreds of miles from producer field to power plants by way of booster stations, at pressures ranging from 100 to 500 psi or more. It is reduced at the power plant to pressures of about 10 psi or less.

Gas is delivered to power boilers at a standard or base pressure which may be four ounces, or eight ounces or as much as two or three psi. Quantities of gas smaller than, say, 17,000 cu ft per hr may be measured with a positive displacement dry type meter indicating cubic feet of gas delivered. When gas is delivered at pressures greater than about four ounces, the positive displacement dry type meter may be equipped with a recording pressure and volume gage so the average pressure maintained can be determined. Large flows of gas may be measured with standard orifice type flow meters.

The pipe which delivers gas to the power plant should be black steel, amply sized, with as few bends as possible. The bends should be long and gradual to keep friction loss to a minimum. All pipe joints must be tight. There should be no sags in the pipeline; condensation may collect in the sags and obstruct the gas flow. See that pipe hangers are

Table I. Comparative heat values of coal, oil and various gases: that is, assuming Btu values given below table, 1000 cu ft natural gas = 6.94 gal oil = 83.3 lb coal = and so on horizontally across each line

Natural Gas Cubic Feet	Oil Gallons	Coal Pounds	Coal Gas Cubic Feet	Coke Oven Gas Cubic Feet	Bituminous Prod. Gas Cubic Feet	Anthracite Prod. Gas Cubic Feet	Total Btu
1000	6.94	83.3	1600	1689	6829	7194	1,000,000
144	1.	12	230	243	986	1036	144,000
24000	167.	2000	38400	40540	164384	173662	24,000,000
625	4.34	52.1	1000	1056	4281	4496	625,000
592	4.11	49.3	947	1000	4056	4259	592,000
146	1.01	12.2	234	247	1000	1050	146,000
139	.97	11.6	222	235	952	1000	139,000

Table is based on: natural gas, 1000 Btu per cu ft; oil, 144,000 Btu per gal; coal gas, 625 Btu per cu ft; coke oven gas, 592 Btu; bituminous producer gas, 146 Btu per cu ft; anthracite producer gas, 139 Btu per cu ft; coal, 12,000 Btu per lb.

Now, if coal has a Btu value of 13,000 Btu per lb, the equivalent cubic feet of natural gas per ton of coal is found as follows: (24,000 (from table) × 13,000 ÷ 12,000, which is 26,000 cu ft.

Table II. Some physical characteristics of natural and manufactured gas

	Natural Gas	Natural Gas	Manufactured Gas
Formula	75-80% CH_4 25-20% C_2H_6	92.8% CH_4 5.4% C_2H_6	---
State at 60° F. and 30 in. mercury	Gas	Gas	Gas
Molecular weight	36.80	17.05	
Specific gravity of gas (air equals 1)	0.661	0.589	0.450
Density of gas, lbs per cubic foot	0.05059	0.0451	0.034
Cubic feet of air to burn one cu. ft. of gas	11.0	9.742	4.73
Btu per cu ft of gas (Gross)	1150.	1038.	550.0
Limits of inflammability % gas, lower limit, in air	4.9	5.3	6.1
Limits of inflammability % gas, upper limit, in air	13.8	14.2	28.1
Max. rate flame propagation in 1" tube, ft/sec	2.4	2.2	5.4

Table III. Comparative data on various commercial fuel gases

Kinds of Fuel Gas	Constituents: Methane	Ethane	Illuminants	Hydrogen	Oxygen	Carbon Monoxide	Carbon Dioxide	Nitrogen	Gross Heating Values (Btu) per Cu Ft	Specific Gravity (Air = 1)	Air for Complete Comb per Cu Ft Gas	Btu per Cu Ft Comb Mixture
Natural—Pittsburgh	82.8	17.1	0.0	0.0	0.0	0.0	0.0	0.1	1136	0.627	10.78	96.50
Natural—Texarkana	96.0	0.0	0.0	0.0	0.0	0.0	0.8	3.2	967	0.57	9.20	94.70
Natural—Cleveland	80.5	18.2	0.0	0.0	0.0	0.0	0.0	1.3	1131	0.65	10.75	96.30
Oil Gas—San Francisco	29.7	0.0	4.4	46.5	0.3	12.4	4.4	2.3	578	0.453	4.88	98.19
Carburetted Water Gas	7.6	2.4	10.7	38.1	0.7	33.4	3.3	3.8	533	0.676	4.38	99.10
Blue Water Gas	0.7	0.0	0.0	47.3	0.6	43.5	3.5	4.4	302	0.559	2.24	93.22
Rich Coke Oven	35.4	0.0	3.2	46.8	0.2	6.4	2.6	5.4	605	0.42	5.15	98.37
Lean Coke Oven	27.3	0.0	1.0	57.5	0.3	6.1	2.1	5.7	497	0.35	4.31	93.61
Bituminous Producer	3.0	0.0	0.0	14.0	0.6	27.0	4.5	50.9	150	0.86	9.65	76.3

Table IV. Boiler efficiencies when burning gas. (C. George Segeler, Utilization Engineer, American Gas Association, *Heating, Piping & Air Conditioning*, February 1948)

Boiler Efficiencies for Mixed Coke Oven and Carburetted Water Gas
545 Btu per cu ft; 13.9 per cent ultimate CO_2

Percent CO_2	Percent excess air	Flue gas temperature, F: 300	400	500	600	700
7	93	78.5	75.5	71.5	68.0	64.5
8	70	79.0	76.0	72.5	69.0	66.0
9	50	79.2	76.5	73.5	70.5	67.5
10	37	79.5	77.0	74.5	71.5	69.0
11	25	80.0	77.5	75.0	72.5	70.0
12	16	80.5	78.0	76.0	73.0	71.0

Boiler Efficiencies for Natural Gas
1000 Btu per cu ft; 11.79 per cent ultimate CO_2

Percent CO_2	Percent excess air	Flue gas temperature, F: 300	400	500	600	700
6	100	77.0	73.0	69.0	66.0	62.0
7	67	78.0	74.0	71.0	68.0	64.5
8	48	78.5	75.0	73.0	70.0	67.0
9	32	79.0	76.0	74.0	71.0	68.5
10	20	79.5	77.0	75.0	72.0	70.0

These efficiencies include "moisture loss" and also a 5-per cent "radiation and unaccounted for loss." It is not felt right to extend the data to the ultimate CO_2 percentage since at least 20 per cent excess air must be allowed in the flue gases as a margin of safety.

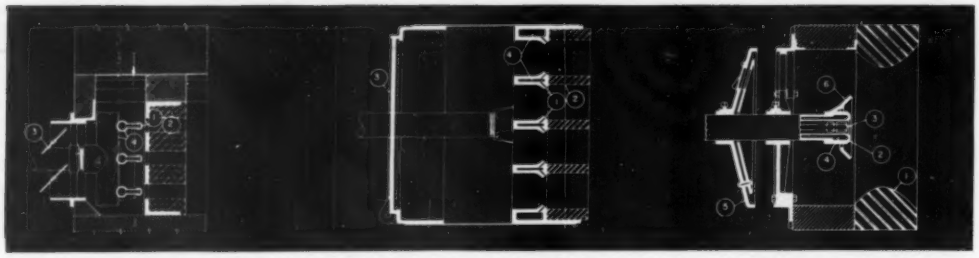


Fig. 5. Cross-section of multi-tube gas burner with gas orifices at center of cross-shaped tubes. Gas orifices 1; refractory tubes 2; air louvers 3; gas manifold 4. This is vertical cross-section

Fig. 6. Cross-section of multitube gas burner with gas orifices at periphery of round tubes. Orifices, 1; refractory tubes 2; air door, 3; gas manifold 4. This is vertical cross-section through one tube row

Fig. 7. Register type burner with gas orifices in center of air stream. Refractory tuyere block 1; gas orifice 2; oil burner 3; gas manifold 4; air register 5; diffuser cone 6

sufficient in number and are kept in good mechanical condition.

Before pipe is placed in the line, it should be swabbed thoroughly to remove all traces of oil, scale, chips. And before the final connection is made, the pipeline should be blown out with air to drive out all dirt.

Horizontal pipelines should drain to the riser, and the riser to the meter should have a drip. The drain pipe below the drip should be fitted with a valve, and with a plug or cap to prevent discharge of gas, should the valve be opened accidentally. A tee instead of an ell should be fitted at the bottom of all risers, with the bottom outlet plugged or capped. Drips should be protected from freezing. Gas pipe exposed to sudden changes in temperature ought to be fitted with expansion joints.

No gas service lines should be connected to the pipe serving the boiler at any point between the meter and the burner or group of burners. Where branch lines are to be connected to a gas pipe, they should take off from the top or side.

Leads from gas header at boiler to individual burners should be proportioned to obtain uniform pressure at each burner. They should be large enough in diameter to insure adequate pressure behind the burner control. If more than one boiler is served from the gas line, a subheader is used, with a shut-off valve for each boiler.

As a special safety feature in the header and subheader system, vent lines are generally specified, to stop gas from entering the combustion chamber when the boiler is shut down. A small vent pipe fitted with a valve is connected to the end of the header and extended to the outside of the building, terminating in a screened weatherproof outlet. For maximum safety, an individual vent line is installed for each boiler.

When the subheader valves and the burner cocks are closed (out of service) and the valve in the vent line is open, any gas that may leak past the subheader valve will pass to the outdoors. The valve in the vent line is, of course, kept closed while the gas burners are in operation.

Shut-off Valves

Each boiler should have a manually-operated main shut-off gas valve of the lubricated plug type, with handle always in position. The on-and-off positions of the handle, with direction of rotation to open and close, should be clearly indicated. There should also be a shut-off valve outside the boiler room to shut off the gas in an emergency. If the boiler is to be shut down a long time, the line may be disconnected and a blind flange, or screwed plug or cap, installed.

Gas Pressure to Burner

Unless the pressure of gas delivered to the boiler furnace is maintained at, or boosted to, the design value of the burner, it may be impossible to operate a sufficient number of a group of burners to carry the boiler load. And even if the burners are operated at a pressure reduced below design value, inability to turn down the gas burners at a sufficient ratio makes it difficult to meet varying load demands on the boiler.

A burner that operates on gas pressure of 8 psi delivers four times more heat than if the gas pressure is only one-half pound.

Each boiler ought to have its own gas regulator at the burner intake manifold to insure a constant pressure. The regulator, where used, should maintain the gas pressure to the manifold within $\pm$ 10 per cent of the burner operating pressure at all rates of flow from maximum to minimum.

Where gas is delivered at too low a pressure to meet burner requirements, a booster is often used to obtain the desired value. Centrifugal boosters, either single or multi-stage, are preferred by gas engineers. Generally they are direct-connected to an electric motor, but may be driven by a steam turbine. In large boiler plants, duplicate sets are installed,

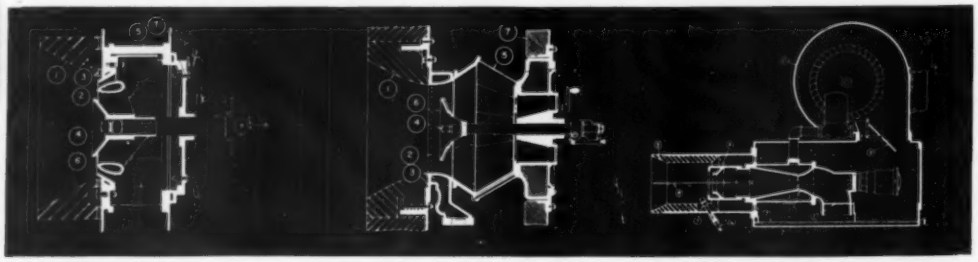


Fig. 8. Register type burner with gas manifold dividing air stream. Refractory tuyere block 1; gas orifices 2; gas manifold 3; oil burner 4; air register 5; diffuser cone 6; outer windbox wall

Fig. 9. Register type burner with gas orifices at periphery of air stream. Refractory tuyere block 1; gas orifices 2; gas manifold 3; oil burner 4; air register 5; diffuser cone 6; outer wind-box wall 7

Fig. 10. Pre-mixing gas burner. Gas orifices 1; primary air control 2; secondary air control 3; flame retention nozzle 4; refractory tunnel 5; spark plug 6; pilot burner 7; flame electrode 8; damper 9; blower 11

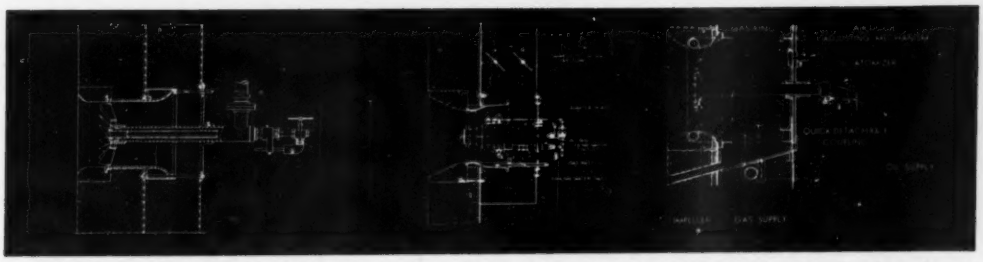


Fig. 11. Recently-developed combination oil-gas burner, natural or forced draft. No movable blades. Air vanes to provide fixed turbulence over entire load range. Adjustable for long or short flame

Fig. 12. In fan-mix burner, gas passes through chamber and out through orifices in end of driver arm. Reaction of discharge rotates driver arm like a turbine, rotating fan which supplies air for combustion of gas

Fig. 13. Combination oil and gas burner, utilizing gas ring in burner throat, from which gas under suitable pressure issues in jets. Mixing of fuel and air by standard air register

one preferably steam-turbine-driven, the other electric-motor-driven.

Boosters must be gas-tight at all times. They should be checked regularly for tightness. If the casing bolts are spaced too far apart, gas leakage may occur at the joint.

Stuffing boxes on gas boosters may cause difficulty. If they are set just tight enough to prevent gas leakage, they may run hot. If they are set just loose enough to keep cool, they may leak gas. Gas engineers suggest use of graphited lead wool or soft graphite asbestos for packing the stuffing boxes. This material is claimed to maintain gas tightness without too much heating of the boxes. Rotary seals of the spring-loaded carbon-ring type have been tried, with excellent results.

Treatment of Feedwater

Proper treatment of feedwater in the gas-fired power boiler is exceedingly important. The boiler must be kept clean internally as well as externally. The gas-fired boiler has an extremely high heat input rate in the portion exposed to radiation from the hot walls of the combustion chamber.

The feedwater should be checked regularly. Adjustments of feedwater treatment should be made at once when tests indicate need of change. Scale and mud must be kept out of the gas-fired boiler. The power engineer may want to place this responsibility for proper feedwater treatment in the hands of a specialist. In that case he would function as an inspector to see that the treatment is checked regularly and corrected whenever necessary. Even a thin coat of scale must be regarded as objectionable in gas-fired boilers.

Proper treatment of feedwater in gas-fired boilers assures freedom from blistered tubes, reduced maintenance costs, less interruption in operation, lower flue gas losses, decreased furnace temperature, less need for taking the boiler out of service for cleaning and repair, and safer use of gas.

Basic Gas Burning Principles

The basic rules for operating a gas burner are simple. The gas pilot (or other igniting devices), valves and burners must be so arranged that, when the pilot only is in operation, the gas from the burner, or any grouping of burners, will ignite positively, without any flashback or without any delay in ignition.

Where a constant-burning pilot is used, the air-and-fuel mixture should ignite freely within the entire operating range of the burner, from maximum down to minimum delivery of heat. When the gas is turned on or off by an automatic control, the burner flames should not flash back to the outside of the boiler. There should be no flashback at any point within the operating range of the burner.

An air-and-gas ratio must be maintained that will insure complete combustion in the furnace space throughout the full design range of the burner.

Backfiring of a gas burner may be due to: gas and air delivery cut down too far, or burner outlet area too large, or gas pressure too low. Sometimes a burner outlet is increased by accidental burning off of the nozzles. This enlargement produces an oversize burner hole; this decreases the velocity of the air-and-gas mixture to the point where combustion occurs within the opening of the burner. When operating at too high a temperature, the burner nozzles may get damaged.

Starting the Gas-Fired Boiler

In starting the gas-fired boiler furnace, its temperature should be brought up gradually, for only a limited volume of gas can be burned in a cold furnace. This rule applies especially to newly-bricked settings. Too rapid expansion of the refractory should be avoided. Raising steam too fast injures the boiler as well as the furnace setting.

The burner flame must be essen-

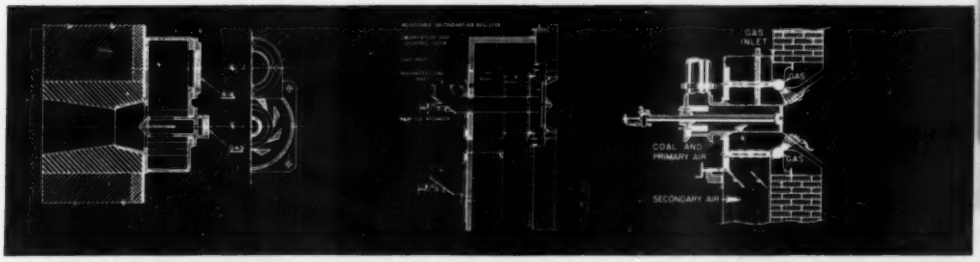


Fig. 14. Nozzle pre-mix burner designed for 5 hp to 300 hp boilers. Operates under manual or automatic control on gas pressures from 4 oz to 3 psi. Uses double venturi principle

Fig. 15. Combination pulverized coal, oil and gas burner for multi-fuel installations. It is equipped with gas ring, burner for pulverized coal and oil atomizer. It is designed to handle all grades of coal, oil or gas

Fig. 16. Combination flare type burner, with gas burning ring in throat. Gas jets directed as shown whirling gas into air stream for good mixing provision for burning pulverized coal and oil as well

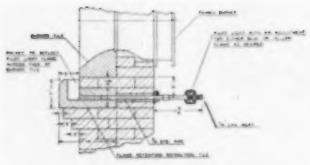


Fig. 17. Method recommended for installing pilot light with fan-mix type burner. Air damper adjusts pilot flame from blue to yellow, latter preferred for ease of observation and checking

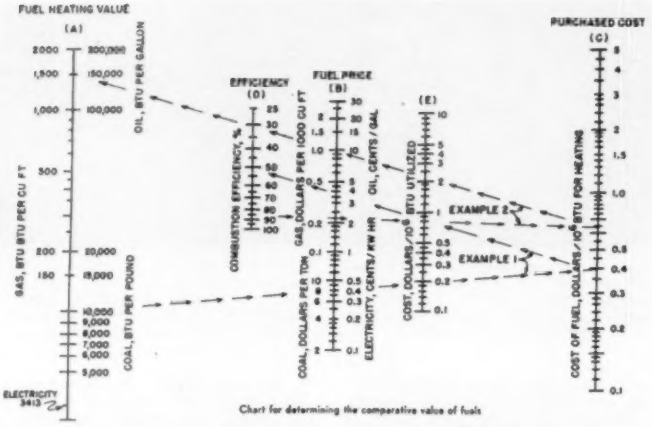


Fig. 18. Chart showing comparative costs of coal, oil and gas fuels

Example:—Coal of 10,000 Btu per lb costs $8 per ton. What is purchased cost per million Btu? With combustion efficiency of 50%, what is utilized cost?

Enter chart at 10,000 Btu on scale A, draw line through $8 per ton scale B, project it to scale C, read $0.40 per million Btu. From this point on scale C, draw line though 50% scale D. Read utilized cost on scale E at $0.80 per million Btu.

If all of 150,000 Btu is available, what price should be paid for it to have the same cost as for coal? Oil combustion efficiency 85%.

From $0.80 on scale E, draw line through 85%, scale D to scale C, thence to 150,000 on scale A. At intersection with scale B, read $0.10 per gal.

tially stable, quiet, and free of pulsations. Pulsations originate through the periodic forming of pockets of partially burned gas that ignites. The causes of the pockets of unburned gas may include: impingement of flames on cold surfaces, unventilated areas in the boiler setting, inadequate supply of air to the burner, poor mixing of air and gas. The remedies may include: reduction of gas input to the burner, changes in draft, replacing the burner with a different type. Air and gas velocities higher than speed of flame propagation might also prevent proper combustion.

If difficulties in gas combustion cannot be remedied by the power engineer, he should ask advice from the industrial service department of the public utility supplying the gas.

When the correct mixture of air and gas is used in the boiler, the gas flame is practically clear, with only a slight hazy appearance. When there is more air than needed to burn the gas, the flame becomes oxidizing. But when there is an excess of gas over the amount of air needed for maintaining perfect combustion, the flame becomes reducing. To obtain the proper flame condition, it is best to start with a reducing flame (an excess of gas over air), gradually increasing the air supply until the proper flame condition is obtained.

Lighting-Off

A high-caliber, well-trained fireman is the primary factor in safe lighting-off, to prevent back-fires and furnace explosions. He must faithfully follow proper lighting-off procedure. A typical procedure is given below. It will be assumed the fireman has assured himself that all drain valves are closed, that there is water in the boiler and that all access and observation doors are closed.

He should then:

1. Check all gas fuel valves at all burners to be sure they are closed.
2. Thoroughly purge the furnace and passes for 5 min. at ¼ of the air flow rate for maximum rating.
3. Reduce the air flow to ¼ of rating through the register of the burner to be lighted, leaving registers of other burners open.
4. Insert a reliable lighting torch, having a substantial flame, into the lighting port of the burner to be lighted and make sure it is located so as to light the pilot promptly if a pilot is used or, if not, the main burner.

   A reliable lighting torch may be made of a dozen turns of ½-in. asbestos rope, secured by a hairpin bend, on a 3-ft length of ⅜-in. diameter steel rod. This torch should be kept immersed in a pot of light oil at the boiler front. Well-designed portable gas or oil burner type torches are also suitable. Do not try to light a burner from hot refractory, or one burner from another or from burning waste thrown into the furnace.
5. Open the main fuel valve at the burner slowly and light the gas, either from the pilot or the torch, in accordance with the manufacturer's instructions.
6. If a main burner does not ignite within 5 sec after its fuel valve is opened, or if the torch, pilot or main burner flames blow out, the fireman should:

   a—Close the main burner fuel valve at once

   b—Remove the torch and turn off the pilot flame, if a pilot is used

   c—Adjust dampers, burner registers and fans for not less than ¼ rated air flow through the setting

   d—Purge the furnace at this rate for at least 5 min before re-adjusting dampers and inserting the torch for another attempt to light off.

It will help the fireman greatly if the consulting engineer and burner manufacturer arrange to have each burner equipped with proper inspection window so that the fireman can see clearly the relative positions of lighting torch, pilot and main burner flames while holding the torch in position and opening the burner gas valve. The arrangement should permit him to stand comfortably erect but to one side of the lighting port.

Typical arrangements are shown in Figs. 17 and 21, and comparable arrangements can be made for other types of burners.

When the boiler is equipped with more than one burner, light one burner at a time. Never turn on all the burners and light them all at once. Do not leave one burner already lit and try to light another burner until absolutely certain that the burner already lit has operated long enough so no slugs of air will flow accidentally from the pipeline and cut off the burner flame. With the flame cut off and the gas flow continuing after the slug of air has left the burner, an explosive mixture would exist in the furnace. Operation of one burner must be safe before starting the next one.

After the boiler has been brought slowly up to full pressure and is on the line, the controls may be switched from manual to automatic, depending on the type of control used. Necessary adjustment can then be made by following the instructions of the manufacturer of gas burner controls.

Automatic Combustion Control

On power boilers today, the value of automatic combustion controls as an aid to the fireman in maintaining constant steam pressure, desired

fuel-air ratio for best combustion, correct, constant furnace draft and desired load distribution among several boilers, is thoroughly understood. The power boiler installed today without some form of automatic combustion control is the exception rather than the rule.

Automatic combustion control as applied to the modern gas-fired boiler is preferably of the modulating type. Three general types of automatic combustion controls are available: 1—fully automatic off-and-on; 2—high-low; 3—modulating.

Off-and-on controls shut off the gas supply to the burner when steam pressure is reached and open the gas supply valve when the steam pressure drops to a predetermined lower value. They are usually not recommended for boilers larger than 75 hp, which are not discussed here.

High-low or two-position controls work the same way except that they do not shut off the gas supply but maintain a flame in the burner at all times and vary the gas flow from maximum to minimum to match the steam demands.

The power boilers we are talking about in this article are usually equipped with modulating controls. These are either of the positioning or measuring type. The positioning type maintains a constant gas-air ratio by positioning mechanical linkages connecting damper-actuating devices with the movement of the gas valve. Metering type controls maintain fuel-air ratio by measuring gas and air flows and using these measurements, by suitable mechanical or electrical amplification, to adjust gas and air flow control mechanisms.

Since metering type controls utilize fundamental laws of gas and air flow, they are able to maintain correct proportions automatically at all times, compensating for variations in barometric conditions and changes in gas pressure.

Various methods of connecting these controls are used, of which Figs. 19 and 20 show two simple and effective ones.

Control systems may, of course, be much more elaborate than these, with complete metering of steam flow, air flow, gas flow, corrections for steam-flow, air flow, master controller to transmit control impulses simultaneously to several boilers and so on. However, when fuel gas is relatively cheap, it pays to keep controls simple, provided they are of the metering type to hold ratios constant over the load range.

A number of extremely reputable and skillful manufacturers of control equipment supply metering type controls that employ the fundamental laws of gas flow and permit turning gas burners on and off without constant re-adjustment of the control to maintain constant fuel-air ratio.

Pilots and Flame Failure Rod

Pilot gas lines are taken off a vertical gas supply line or off the top side of a horizontal line, and always upstream from the main burner valves and regulators. Constant burning pilots are required on the fully-automatic boilers operating on the on-and-off principle. They must burn continuously to assure safe and reliable ignition. On other types of boilers, the ignition may be effected either from a fixed pilot or a portable hand torch; actually, the pilot flame is required only during the moment of burner ignition.

Where a flame rod is used instead of a continuous burning pilot, wired to a manual reset valve, be sure it operates properly in case of low water, or flame failure, or when the steam pressure has reached its maximum. Make certain that the flame safeguard protection equipment is always in proper operation. The gas to both main burner and pilot must shut off in case of flame failure.

To prevent possibility of explosions which may occur when lighting-off gas-fired boilers, several precautions can be taken to help the fireman. The modern water-wall furnace boiler suffers the worst, in physical damage and cost of outage, from a furnace explosion. The hazard is greatest when lighting-off a cold boiler or hurriedly relighting after an unscheduled shut-down. Damage from lighting-off explosions seems to be greater than with "firing" explosions.

Safety Control System

Reliable pilots for each burner seem to offset much of the lighting-off trouble and such pilots are highly necessary when firing at low rating or when warming up a boiler before putting it on the line.

However, one of the principal causes of burner backfiring and furnace explosions is leaving burner cocks open accidentally, permitting gas to flow into a furnace upon opening the main fuel valve before lighting off. The resulting accumulation of gas is usually ignited by the insertion of the lighting torch.

To prevent this, a special gas control cock and gas safety control system, shown in Fig. 24, has been developed. It was described in some detail in the September issue and additional details are given in Ref. 10. Briefly, it consists of a special cock for each burner, having a side passage, which is open when the cock closes the gas passage leading from supply main to burner. The side passages of all the burner cocks are connected in series by tubing, to pass gas or compressed air controlling a pressure checking switch. If all burner cocks are not fully closed, the control air pressure switch holds the main gas line valve closed so no gas can be turned into the burners. When all cocks are fully closed before lighting-off, the pressure switch will open, energizing the gas shut-off valve, which can then be opened manually. Then the fireman can open individual gas cocks and light-off each burner as

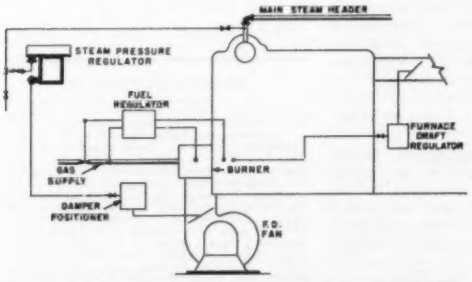


Fig. 19. Typical arrangement of sequential automatic combustion control for gas fired boiler recommended for installations where relatively constant supply of gas is assured

When there is no possibility of wide variations or even total failure of gas supply, this system is preferred. In this control, air flow rate follows steam flow rate (as measured by steam pressure); and fuel flow rate, measured by burner drop, is automatically readjusted to follow air flow rate. This minimizes possibility of over-rich combustion, gives safer response in case fan fails.

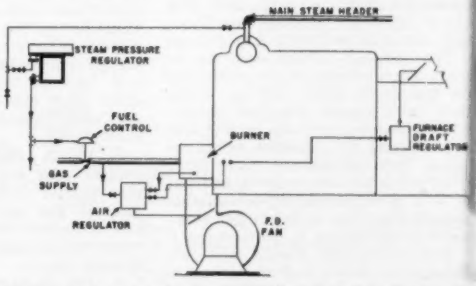


Fig. 20. Another typical arrangement of sequential automatic combustion control, often preferred if there is a possibility of wide variation or failure of gas supply

This situation often occurs in industrial plants where gas fuel supplies both boilers and industrial process furnaces. To maintain production, gas supply must be maintained to these furnaces, and the boilers must take what gas is left, making up any deficiency with other fuels. This system controls fuel flow from steam flow rate and the air flow follows the fuel flow.

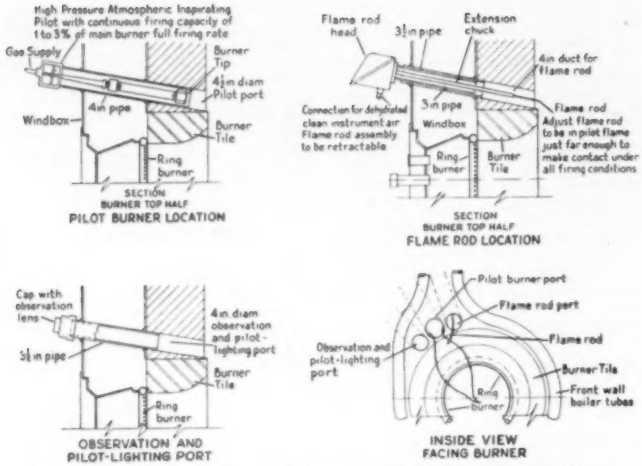


Fig. 21. Suggested application of combustion safeguard to ring-type gas burner

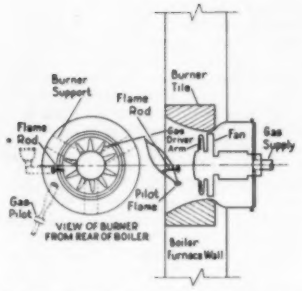


Fig. 22. Suggested application of combustion safeguard to fan-mix type gas burner

explained above. These cocks are not used, of course, where there is only one burner.

Combustion Safeguards

Combustion Safeguards, often called flame failure controls, are often used on gas-fired boilers. They are control devices that sense the presence of a flame and, if the flame fails, shut off the fuel and sound an alarm. The term does not usually refer to other safety devices such as plain pilots, safety control cocks, low-fuel-pressure controls and draft fan interlocks.

Flame failure controls for gas firing must be of the flame-conductivity or flame rectification type, because the gas flame is non-luminous and would not influence a photoelectric type of flame control, which is suitable for the luminous flame of oil firing. In the flame-conductivity or rectification type, a metal rod projects into the path of the flame, which completes an electric circuit when it touches the rod. This circuit, through suitable amplification, actuates fuel controls or alarms.

These flame failure controls or combustion safeguards are often used on boilers of below 500 hp where they have proved practical, worthwhile protection and are simpler and not exposed to excessive temperatures. But on boilers above that, their use is not too common, because of lack of operating experience, although such use on the larger manual-lighted boilers is encouraged.

Experience has shown that, although the flame rod cannot sense unburned gas during lighting-off, it will detect the presence of the pilot flame. Hence a strong reliable pilot flame is necessary in such cases as a valuable safeguard. The pilot flame and flame rod must be properly installed so that the rod not only will make contact with the pilot flame but also with the main burner flame and not cause false shut-downs. Figures 21, 22 and 23 show how this is done in the case of the widely-used ring-type, gun-type and fan-mix types of burners.

In these, if main burner flames are un-piloted, the flames may move with changing firing rates and may lose contact with the rod. In most cases, gas to each main burner should be controlled by an approved manual-opening safety shut-off valve so that fuel to that burner only will be shut off if its flame fails.

Recommendations

One insurance company recommends the following:

1. Provide a continuous fixed pre-mixing pilot for each burner. A high-pressure (over 1 psig) atmospheric inspirating pilot burner is recommended, large enough and premixed enough to furnish a reliable flame with main burner off and forced and induced draft at maximum rating. For radiant burners, a low-pressure atmospheric inspirating pilot may be satisfactory. Ring and fan-mix burners usually require pilot capacity of 1 to 3 per cent of main burner; h-p gun types a little less.

2. Install the approved safety control cock and system, to insure that burner cocks are shut before manual gas safety shut-off valve can be opened. This system also protects against gas pressure failure during firing.

3. On single-burner boilers, install protection against low gas pressure (not needed if flame-failure control is used).

4. Interlock main safety shut-off gas valve with electrically-driven draft fans where continuous operation of fans is necessary at all firing rates. Interlocks should put I. D. fan into operation first, then F. D. fan, before safety shut-off gas valve can be opened; while failure of either fan should shut off gas.

5. Approved flame-rod type combustion safeguards are desirable on boilers 200 to 500 hp where practical. They should be connected at first to sound an alarm; later, when proved reliable after adjustments, they can be arranged to cut off fuel supply also.

General Comments on Gas Burning

The power engineer must maintain the valve assembly of the gas-burner installation tight, whatever the position of the valve.

In larger boiler installations, where an engineer is always on duty, there may be means available for holding the gas valve open manually during interruption of the electricity supply. On this point the Omaha (Nebraska) Industrial Gas Code states in Part 8, paragraph 6:

"On large boilers with constant attendance, it will be permissible either to use a safety shut-off valve equipped with means for manually holding the valve open in case of emergency, or install a by-pass around the safety valve with the valve in the by-pass sealed or locked shut. Constant attendance is considered accomplished by the presence of a licensed operator in the boiler room at all times that the boiler is in operation, charged with the sole responsibility of attending that boiler or group of boilers."

Gas engineers suggest that the in-

ACKNOWLEDGEMENTS

For data on equipment used in gas firing of power boilers, we are indebted to the following: The Anthony Co.; The Babcock & Wilcox Co.; J. P. Badenhausen; Bailey Meter Co.; W. N. Best Engineering Co. Inc.; Bethlehem Steel Co.; Wm. Bros Boiler & Mfg. Co.; Coen Co.; Combustion Engineering-Superheater, Inc.; Combustion Equipment Co.; Combustion Control Corp.; Condenser Service & Eng. Co.; Coppus Engineering Corp.; Denver Fire Clay Co.; Eclipse Fuel Eng. Co.; The Engineer Co.; Erie City Iron Works; Foster-Wheeler Corp.; Hagan Corp.; Hauck Mfg. Co.; Hays Corp.; Industrial Gas Eng. Co.; The Inferno Co.; International Combustion Corp.; Iron Fireman Mfg. Co.; E. Keeler Co.; Lee B. Mettler; Murray Iron Works; National Airoil Burner Co.; Natural Gas Equipment, Inc.; North American Mfg. Co.; Peabody Engineering Corp.; Ray Oil Burner Co.; Republic Flow Meters Co.; Riley Stoker Corp.; Roberts-Gordon Appliance Corp.; W. S. Rockwell Co.; Springfield Boiler Co.; Tate-Jones & Co., Inc.; Todd Shipyards Corp., Combustion Equipment Div.; Union Iron Works; Henry Vogt Machine Co.; Webster Engineering Co.; Western Products, Inc.; Wheelco Instruments; The Wickes Boiler Co.; John Zink Co.; J. A. Zurn Mfg. Co.

dividual gas burner should have a turn down ratio between maximum and minimum capacity of not less than three to one, and it should have a variation of not more than one per cent in CO_2 content of furnace gases between the maximum and minimum firing rates.

In operating a gas-fired boiler, the power engineer should always bear in mind that even safety devices fail at times or get out of order and therefore need careful watching. Too much dependence cannot be placed on automatic controls and safety equipment.

Explosion Relief

Explosion relief doors may be used to advantage in gas-fired boilers. They should be placed in that portion of the boiler which encloses the largest pocket volume, usually the combustion chamber. The explosion relief door should be as large as possible to quickly release the force of explosion, and there should be as little weight as possible against its opening, so that there is an instant response to the pressure wave of the explosion. Any kind of explosion door, however, ought to be considered only as a poor compromise to lack of proper attention to the operation of a gas-fired boiler.

Another type of explosion relief which has been used with much benefit between the top drums of some water tube boilers is the setting of lightweight insulating brick loosely in place.

Some boilers, for instance the horizontal return tubular, have large cast-iron doors permitting access to the tubes for cleaning. These doors are a possible source of danger to the operator, unless they are high enough to pass over the engineer's head when swinging open. It is desirable to replace such doors with lightweight sheet-iron doors lined with asbestos, and to provide these doors with guards to limit their movement to any amount sufficient to relieve the force of an explosion without endangering the operator.

A. D. Frydendall, (Ref. 1) has called attention to two hazards that may be introduced in the operation of gas-fired boilers, as follows:

"In the operation of any boiler, it is necessary to meet load fluctuation by increasing or decreasing the flow of gas to the burners. With a continual decrease in load, the automatic steam pressure controller will turn the gas down in an endeavor to keep the heat input in step with the steam demand until the pressure at the burner is too low for satisfactory combustion and with a heavy drop in load may turn the gas off completely.

"This situation introduces two hazards. If the damper is not a good fit in its frame, the draft at low burner operation may be so great that the flame will be pulled off the burner completely and an explosion occur when and if re-ignition takes place. The closing of the main control valve with a sudden drop in steam load introduces the same hazard. To prevent this happening, the controller operating the fuel valve should be slow in operation and its minimum position limited so that the turndown pressure will not fall below 1½ to 2 ounces for multijet burners and ½ lb for register type burners."

Baffling for Gas-Fired Boilers

The standard methods of boiler baffling are approved generally when installing gas burners in three and four-drum boilers. It may be desirable, in some installations, to remove some tile so as to eliminate dead air pockets that would reduce the available heating surface.

When installing gas burners in horizontal straight-tube boilers, no baffle changes are necessary for vertical baffles and front firing—if the exposed black surface and the length of the combustion chamber are ample. However, if such a boiler is changed to rear firing, it is desirable to cut off the first vertical baffle up to the third row of tubes and to place a horizontal baffle on the second row of tubes which extends from the front baffle to the rear wall of the boiler. The bottom of the rear vertical baffle will have to be cut off to obtain sufficient space for the hot gases to pass through without too much loss of draft.

Boilers baffled horizontally are usually low set and have C-tile on the bottom row of tubes to eliminate smoke. When gas burners are installed, the C-tile is customarily removed, and T-tile substituted on the second row of tubes.

Most boilers, when properly baffled, will have pockets which collect gas if a gas valve or cock should leak after shutdown of the furnace. As a safety precaution, it is advisable to put openings in the baffles at a high point to prevent the possible collection of gas. These openings need not be large. Two or three holes about 2 by 2 in., spaced uni-

(Continued on page 106)

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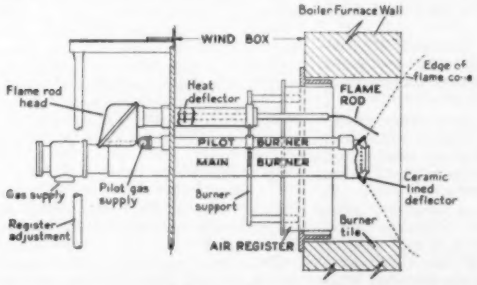


Fig. 23. Suggested application of combustion safeguard to high-pressure gun-type gas burner

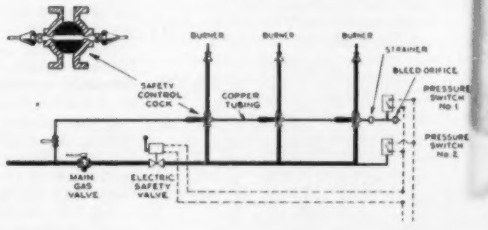


Fig. 24. Fundamental principle of gas safety control system for power boilers, showing use of gas safety control cock. Gas cocks on each burner control checking pressure switch that in turn controls electric valve. Burner cocks must all be closed before electric valve can be opened by hand to admit gas to burners in lighting-off

What Can Wind Power Do for Us?

In appraising value of wind power to a public utility system, author gives data to justify following statements: . . . 1—Wind power is technically feasible . . . 2—Wind power is probably non-competitive at present . . . 3—There are few duties for which wind alone is adequate . . . 4—Combination of wind power with internal combustion power has some strong advantages . . . 5—Combination of wind power and hydro power with seasonal storage has some strong advantages

By GEORGE A. WHETSTONE
Associate Professor, Department of Civil Engineering
Texas Technological College

Grandpa's Knob wind power plant operated from 1941 to 1945

LET US CONSIDER the above points in the order given.

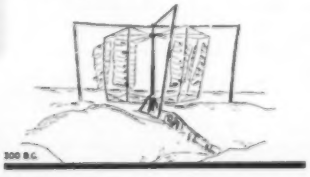
1. Wind power is technically feasible.

A number of wind-driven devices have been built and studied. These include the familiar wind mill of West Texas, the larger and more picturesque windmills of Holland, and the wind-charger for providing electricity at isolated farms. The first two are used for intermittent pumping involving moderate power requirements, and the last one is actually used for power generation of a few kilowatts capacity.

Wind generation has been attempted and has been proved technically, but not economically, satisfactory on a larger scale.

The most important of these tests was carried out under the direction of P. C. Putnam with a most impressive list of consultants. (Ref. 1 at end of article.) It was backed financially to the extent of $1,250,000 by the S. Morgan Smith Co., one of the leading manufacturers of hydroelectric power equipment.

Putnam has published (1) an account of the studies made of wind behavior, of component stresses in the wind turbine and its tower, and of possible improvements for a production model. He is convinced that the problems of physical design are essentially solved.



Primitive forms of windmills were used in China centuries before the Christian era

Briefly, the experiment took the form of a test unit rated at 1250 kw, erected on a hill known as Grandpa's Knob in Vermont. The turbine runner consisted of two stainless steel blades very similar to an airplane propeller but 175 ft in diameter. The hub was 120 ft above ground. Winds above 17 mph caused the unit to function and to supply energy to the lines of the Central Vermont Public Service Corp.

The unit ran from October 1941 until February 1943, when a bearing failure resulted in a shutdown of more than 24 months due to the difficulties of replacement in wartime. It ran again on a new bearing for 23 days in March 1945, until a blade failure led to Smith's reluctantly abandoning the project.

It is reported (2) that there were 88 wind-driven generators in service in Denmark in 1944 with capacities from 30 to 70 kw. One of the 70-kw sets generated 118,729 kwhr in 1947, even though it was shut down nights for lack of load.

A 100-kw aero-generator was erected at Yalta, Russia, in 1931. *Engineering* (2) quotes an unnamed source: "It is known to have run for 10 years but was destroyed during the war."

The North of Scotland Hydro-Electric Board has a 100-kw wind set under construction for erection on a coastal headland.

Other studies have been made calling for much larger units than the 30 to 100-kw stations functioning in Europe or even than the 1250-kw Grandpa's Knob project.

Honnef (1, 2), a German, proposed a 50,000-kw plant consisting of five wheels on a tower 1000 ft or more in height. More recently, Percy H. Thomas, an engineer with the Federal Power Commission, has prepared a series of studies (3) on wind power, leading to the design of a two-blade 7500-kw unit and of a three-blade 6500-kw unit on towers about 500 ft high. This emphasis on height is prompted by the great mass of data showing increase of wind velocity with height; and it should be recalled that power is approximately proportional to the cube of the velocity.

In summary, it would seem safe to conclude that the wind turbine is technically feasible but that the "ideal" wind turbine has not yet been built. Our rather limited experience to date has led to many improvements, and it is only reasonable to assume that further experience will further perfect the performance and also reduce the cost. The author presented these data before the Panhandle-Plains Section of the AIEE at Amarillo, Texas, in September 1950. He then gave the following comments on his remaining points.

2. Wind power is probably non-competitive at present.

Power is a highly competitive field, in the sense that each type of fuel or hydro or wind must pass a rigid economic examination before it is selected for installation. The power executive compares the cost per kilowatt installed and cost per kilowatt-hour generated and properly selects the most economical plant, taking into account such factors as hydro- or wind-sites available, probable price of fuel, the existing system to which the plant is to be added (this point has a great deal to do with the relative value of capacity measured in kilowatts, and energy in kilowatt-hours), and the type of load to be served.

Thus Smith abandoned the Grandpa's Knob test after the blade failure of 1945 because an economic analysis showed that the Central Vermont

Public Service Corp. could afford to pay no more than about $125 per kw for wind turbines, whereas the cost of installing them would be about $190 per kw. Putnam had proposed savings, which, if realized, would have more than bridged this gap, but it would have cost several hundred thousand dollars to check his estimates. The stockholders balked.

Of the 88 Danish wind turbines of 1944, but 58 remained in 1949.

Thus it would seem that present fuel and hydro costs are sufficiently low to exclude wind power for some time yet, at least in most parts of the world.

Wind power, however, will quite likely become practical in the not too distant future for the following reasons:

A. Wind is free. There are no fuel costs, no coal strikes, and no water-right controversies over it.

B. Wind is a perpetual non-wasting source of energy. We cannot exhaust it as we can fuel or atomic energy and it is not destroyed by silting as many of our reservoir sites for water power are.

C. Though the wind is very unreliable at any given instant, its monthly averages are fairly stable. Moreover, if a number of widely scattered points are connected to a network even the instantaneous total of wind generation is not zero. In other words, calms are local phenomena. Thus with diversification, wind can be counted on for some firm power.

D. The cost of wind turbines will no doubt decrease due to foreign research particularly in countries with critical shortages in fuel and hydro potential.

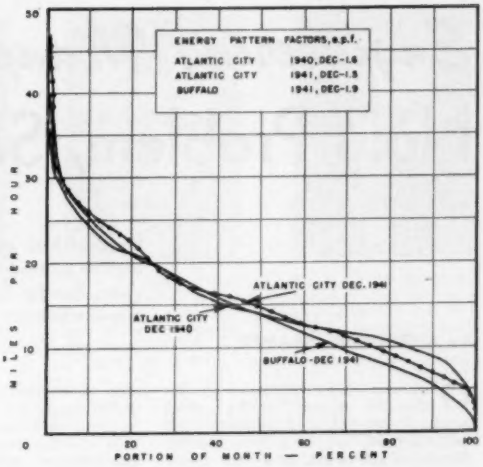
E. As we work poorer coal deposits with higher wages and higher freight rates, and as more and more natural gas is consumed, or even with the same gas production as the market is enlarged by pipelines to cities thousands of miles from the producing fields the cost of fuel is bound to increase.

F. It is self evident that the first hydroelectric plant in a region will develop the most economic powersite if its capitalization is sufficient to cover it. The next plant takes the next most desirable site and so on. Thus, in general, the sites remaining at any time are less economical than the ones developed. This law is not fully operative at the moment because of the multiple-purpose projects in which power is but one of a number of uses of the entire development.

3. There are few duties for which wind alone is adequate.

A single wind turbine will be idle much of the time. Even with reasonable allowance for diversity of wind patterns the firm capacity will be a small percentage of the installed capacity.

This sort of power might be utilized by pumping into reservoirs. For example at an installation such as Elephant Butte Dam, where water can be passed through the turbines and then impounded again in a re-regulating reservoir for timed release, it might prove economical to pump by wind from the lower to the higher reservoir for re-use. It is doubtful if electric generation would be employed in this operation.



Typical wind duration curves and energy pattern factors, constructed by Federal Power Commission. Observed wind velocities at Buffalo, N. Y., December 1941, and at Atlantic City, N. J., December 1940 and December 1941. Many other such duration curves, plotted from U. S. Weather Bureau data, have shapes much like these

Perhaps some electro-metallurgical processes exist where an intermittent power supply with a reasonably predictable weekly average would be sufficient. If so, wind alone would serve.

Evidently wind is comparable to run-of-the-river hydro power, and run of a very erratic river at that. Alone it lacks the possibility inherent in hydro power of ponding, whereby the excess water during hours of small load can be stored for use on the peak load.

Wind, then, will probably always be used in conjunction with one or more other power sources. However, this is hardly a serious limitation at present, since nearly all plants are interconnected with other plants in a power pool. As a contributor to the pool, wind power can furnish many kilowatt-hours a year. These would be reflected in a saving in fuel or in water not released from the reservoir.

4. The combination of wind and internal combustion power has some strong advantages.

The large majority, in number—not in capacity or in production, of the small plants, at least in Texas, are internal combustion installations (4). Most of these plants have interconnection on a standby or emergency basis but in general they produce what they sell quite closely. For a single unit a Diesel engine is much more flexible than steam in following the load. Like hydro it can be brought from full-load to no-load and back in a few minutes or even seconds.

Diesel and wind would thus complement each other nicely. Every kilowatt-hour generated by wind represents a fuel saving, and the Diesel could follow the fluctuating load-minus-wind-generation curve as well as it could the load curve alone.

5. The combination of wind and hydro-with-seasonal-storage has some strong advantages.

A hydro plant with seasonal storage has normally a full reservoir for only a few weeks during and just after the annual flood. For most of the rest of the year the water passed through the turbines plus the losses to evaporation and seepage exceed the reservoir inflow. Thus both the capacity and the total annual energy have rather definite limits. Usually when a powerhouse is built provison is made for increasing the installed capacity at some later time. Thus as load increases on a hydro plant it would seem advisable to consider the practicability of increasing system capacity by adding one or more hydraulic turbines and of increasing the annual energy output by addition of some wind turbines. The wind would be used as it blew and the water held back to be doled out as needed.

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4.—*Electrical World*, 30 January 1950, page 109 (Annual Statistical Issue). New York. The figures given for Texas are:

Water power	26 plants	209,615 kw
Steam power	53 plants	1,844,060 kw
Internal combust.	122 plants	158,047 kw

Engineering Manpower—Nation's No. 1 Problem, Says Compton

Head of MIT and Hoover medalist at Winter Meeting of the American Institute of Electrical Engineers warns industry of the need to find promising young men for jobs of increasing responsibility. Dr. Compton's address was only one element of a varied and important technical convention but it was a very significant one

By ANDREW W. KRAMER

ONE was easily intrigued by the thought, indeed by the actual accomplishment, of a vacuum-tube amplifier 30 feet long lying at the bottom of the ocean, or by the seemingly reckless abandon with which electrical manufacturers' representatives dared the industry to give them orders for 200,000 kilowatt turbine generators, or by any of a score of other technical achievements of a high order considered at the Winter Meeting of the American Institute of Electrical Engineers in New York, the week of January 22, but perhaps the most dishearteningly significant thought instilled in the minds of those attending this great meeting had to do with Dr. Karl Compton's warnings concerning engineering *manpower*.

Judging from the large number of technical papers presented at some 68 sessions during the week, and from the content of these papers, it is obvious the electrical engineers are well equipped to solve almost any technical problem that may arise, but they are not in a position to solve the manpower problem that is going to present itself in the years ahead, unless the enrollment in our engineering colleges undergoes decided improvement.

The discovery of men qualified to handle key posts in the present mobilization is the *nation's number one problem*, said Dr. Karl Compton in his address, accepting the Hoover Medal, presented to him at this meeting. He advocated that the business world make a conscious effort to find promising young men and to try them out in jobs of increasing responsibility. This, he said, may turn out to be far more significant in the final outcome of our present national emergency than the much more publicized handling of selective draft.

Dr. Compton's warnings were borne out by Titus LeClair, President of the Institute. While the enrollment of engineering students was stimulated by war conditions during the past decade, now, Mr. LeClair pointed out, it is beginning to drop because of rumors concerning a surplus of engineers. This year some 31,000 engineers will be graduated but this will decrease to 15,000 in 1954 and the number of high school enrollments indicate further reductions beyond 1954 unless more high school graduates go to college, or a higher percentage than formerly choose engineering courses.

If one had any doubts concerning the importance of the engineer in society, he could have derived stimulating inspiration from the address of Dr. Vannevar Bush upon the presentation of the John Fritz Medal

Fig. 1. Titus G. LeClair, President of the AIEE 1950-51. Mr. LeClair is chief electrical engineer of the Commonwealth Edison Co., Chicago, Ill.

to Dr. Bush. "The engineer," said Dr. Bush, "is in every sense the builder of the physical aspects of society on which *all other modern aspects* depend. From ancient times, its cities, bridges, and roads have risen under his hands. He has made transportation swift and secure; he has brought the exotic to our doors and sent the products of our machines to the far corners of the world. He bridges the gap between the dream and the reality, and has made our modern world a marvel of speed, precision and durability.

And, this meeting, by virtue of the almost two hundred technical papers presented at its sessions, was eloquent testimony of the complex nature of the art and the need for rigid and thorough training of engineering students, especially in the newer branches of control and communication. The day when any bright young man could assimilate the basic knowledge for an engineering career in a four year engineering course or by actual work in the field and some buring of the midnight oil, is just about over, at least as far as the technical achievements in engineering are concerned. No doubt there will always be a few Charlie (E) Wilsons who by the sheer force of their personality and executive ability will rise to the topmost executive positions in the industry, but Charlie Wilson himself does not claim to be an engineer.

Need for Training in Basic Sciences

As brought out by the papers at this meeting, the electrical engineer of today must have a most thorough grounding in the basic sciences—physics, mathematics and chemistry. The design and construction of a rotor for a 150,000-kw alternator today demands the most exacting knowledge of mechanics, of materials, and of electrical science coupled with experience one can imagine. Such a rotor, weighing 50 tons and spinning at 3600 rpm leaves no room for inspired guesswork, or for simple experimental methods. The suppression or elimination of double frequency vibration in such a rotor, for example, calls for the most advanced kind of electrical and mechanical knowledge we can put forth.

Similarly, the design of complex electronic circuits, the development of new types of electron tubes and the application of these tubes and circuits to new uses, call for the utmost knowledge and understanding of the basic principles of physics and mathematics. An entire session was devoted to the subject of electronic education, and one had only to listen to the pleas of the professors of our engineering colleges at this session for more thorough groundwork in the basic sciences, to realize how important this was in this complex electrical world. While there was spirited, interesting discussion at this session, and some argument, basically the professors were in agreement and the arguments were of a semantic rather than fundamental nature.

While the technical papers covered

practically the entire range of electrical engineering, a considerable proportion were of specific interest to power engineers, indeed there were two whole sessions on industrial power systems and one on power generation. The latter was of general interest because the papers discussed the progress in the development of large turbine generators as well as in auxiliary equipment. It was at this session that representatives of the large electrical companies indicated confidence in their ability to design and manufacture electric generators of 200,000 kw capacity. At the present time 3600 rpm machines of 125,000 kw capacity are being installed and tentative quotations have been made on 3600 rpm machines of 180,000 kva (144,000 kw at 0.8 pf).

Fig. 2. Dr. Karl T. Compton, Chairman of the Corporation of Massachusetts Institute of Technology, who received the Hoover Medal for 1950

Fig. 3. Dr. Vannevar Bush, director of OSRD during the war and now President of the Carnegie Institute, recipient of the John Fritz Medal

Fig. 4. Otto B. Blackwell, former assistant vice president of the A. T. & T. Co. who was awarded the Edison Medal for his pioneer contributions to telephony

Developments in Turbine Generators

The trend in recent years has been towards the increasing size of 3600 rpm machines. Figure 5 reproduced here from the paper by Huntley and Taylor of the General Electric Co. shows the increase in basic kva rating of 3600 rpm generators, both air-cooled and hydrogen cooled, over the years since 1910. For comparison data are also included on 1800 rpm machines. The rating scale indicates the nameplate rating in kva, which in the case of hydrogen-cooled machines is based on 0.5 psi hydrogen pressure. Starting about 1939 advantage was taken of the improved cooling effect obtained by increasing the hydrogen pressure to 15 psi gage, for which a 15 per cent increase in capacity was obtained. And in 1945 a further increase was recognized for pressures up to 25 or 30 psi. In the discussion of the Huntley-Taylor paper, Mr. Lane of the American Gas & Electric Corp. pointed out that the No. 5 unit at Twin Branch Station had been operating successfully with 25 psi hydrogen pressure since 1945.

The phenomenal growth in capacity of 3600 rpm generators in the past 20 years has not come about because of any inherent advantages over the well established 4-pole 1800 rpm machines. Actually, as pointed out by H. D. Taylor, the higher speed generators are somewhat bulkier, heavier and less efficient, and are subject to quite a number of distinctive problems and limitations. The advantages of the 3600 rpm design are all to be found in the turbine end of the set where the quest for ever-higher thermal efficiency and over-all economy of power production has led to continual increases in steam pressures and temperatures. To meet these modern steam conditions, it has been found both technically and economically necessary to use the highest feasible speed of rotation, which permits minimum diameters of turbine shells and minimum numbers of stages. The production of increasingly large, high-speed generators to go with these turbines has been an intensely interesting development.

Generator voltages came in for general discussion at this session. Irving Moultrop, retired engineer of the Boston Edison Co., foresaw the need for 200,000 kw generating units, and voltages of triple and double present-day voltages. N. E. Funk of Philadelphia did not agree either in the need for large units of 200,000 kw capacity or such voltages as Mr. Moultrop foresaw. He believed that the voltage requirements would lie somewhere between 14,000 and 22,000 volts but he saw no need for doubling or tripling present voltages. In this, the electrical manufacturers seemed to agree more with Mr. Funk than with Mr. Moultrop. They feel that there is an optimum voltage for a given size generator. As the capacity of the generators go up, the voltage also rises, but not in the proportion suggested by Mr. Moultrop. We have had 22,000 v generators operating in this country for a number of years, but we have never gone to the 33 kv used widely in England. In commenting on the question of generator voltage, Mr. Lane of the American Gas & Electric Co. pointed out that the question of higher generator voltage was not so much a problem of generator design, but of generator connections. The main generator leads of very large generators, from the machine to the step-up transformers, he said, were very massive and costly where low voltages were used, and by going to higher voltages the amount of copper in these connecting leads could be greatly reduced.

Future Generator Developments

Irving Moultrop, in his discussion of future requirements, indicated the need for higher steam temperatures and foresaw temperatures as high as 2000 F. Mr. Johnston of Westinghouse doubted very much whether such temperatures could ever be attained. He pointed out that the industry is now ready to build steam turbines for operation at 1100 F. As to other equipment, Mr. Johnston said that today, transformers can be built as large as we can ship them, indeed we can make them a great deal larger.

The question of comparative costs between that of generating stations and distribution and transmission facilities was also touched upon. It was implied that the distribution costs were higher in proportion than they should be, but this point was defended by Herman Halpern of the Commonwealth Edison Co. He cited the tremendous strides made in distribution and transmission techniques. The cable people, he pointed out, had led the way towards the use of higher temperatures in un-

(Continued on page 128)

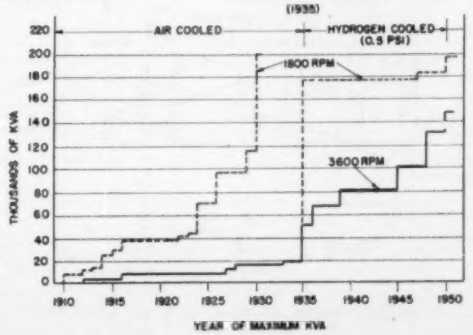

Fig. 5. Chart showing increase in rating of 3600 and 1800 rpm turbine generators since 1910

H. R. REESE and O. N. BRYANT, Turbine Engineers,
Westinghouse Electric Corp., South Philadelphia, Pa.

Explain

THE REHEAT TURBINE and Its Control

After a period in which attention was fixed on raising total steam temperatures, reheat is staging a come-back . . . Reason:—it gives 4 to 5 per cent efficiency in addition to that gained by raising temperature of steam to 1000 F or 1050 F . . . Authors explain why this is so, and how to figure the gain . . . They show many different arrangements of reheat turbines . . . They also show, with control diagram, how modern reheat turbine operation is as simple and reliable as that of non-reheat units

REHEAT in the modern turbine-generator boiler unit is showing a major gain in efficiency for power generation at an attractive over-all cost. At present operating temperatures of 1000 and 1050 F, the gain in thermal efficiency through reheat is between 4 and 5 per cent. Modern boilers for superheating and reheating have been developed to the point where they are little, if any, more difficult to operate than boilers without reheat operating in the same pressure and temperature range. And modern reheat turbine controls have been simplified to the point where operation is as simple and reliable as with conventional non-reheat units used in central stations for many years.

Reheating was used in the 20's so that inlet pressure could be increased without moisture in the exhaust exceeding limitations of materials then used in turbine construction and to improve thermal efficiency.

During the 30's, alloy-steel materials were developed that permitted higher initial steam temperatures and pressures. Water catchers for moisture removal, and the addition of erosion-resistant strips attached to the inlet edges of the low-pressure rotating blades, reduced water-erosion problems. There were so many gains to be made in these other directions, and reheat controls at that time were so complex, that attention was diverted from the use of reheat from the time being. Today increasing fuel costs have revived interest in the improved thermal efficiency of the reheat cycle.

Why Reheat?

Reheating improves thermal efficiency of a steam turbine in much the same manner as superheating. In the simple one-stage reheat cycle in common use today, as shown in Fig. 1, steam exhausts from the high-pressure turbine element to the reheater, where it is again raised to nearly its initial superheated temperature. It then returns to the intermediate-pressure element where it continues on through the turbine-blade path, exhausting to the condenser. It continues from the condenser through the feedwater system and returns to the boiler, thus completing the cycle. Reheat can be added directly from the burners, from a heat exchanger using steam from the boiler, or from a combination of these two methods. Only the fuel-fired method is used today because of the low thermal gain for steam reheating and because of the complexity of controls necessary for the combination method.

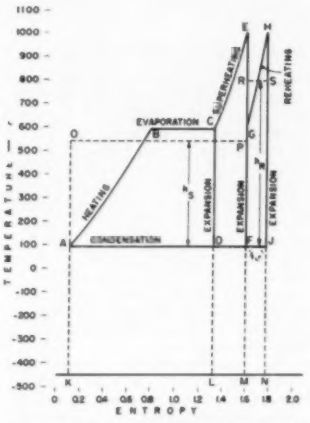

Fig. 2. Reheating adds an additional peak on the ideal temperature-entropy diagram similar to the peak added by superheating. If height h_R of rectangle FRSJF drawn equivalent to the heat converted to useful work by reheating is greater than height h_s of rectangle AOPFA, drawn equivalent to the heat converted to useful work by heating and superheating, reheating increases over-all efficiency of the turbine

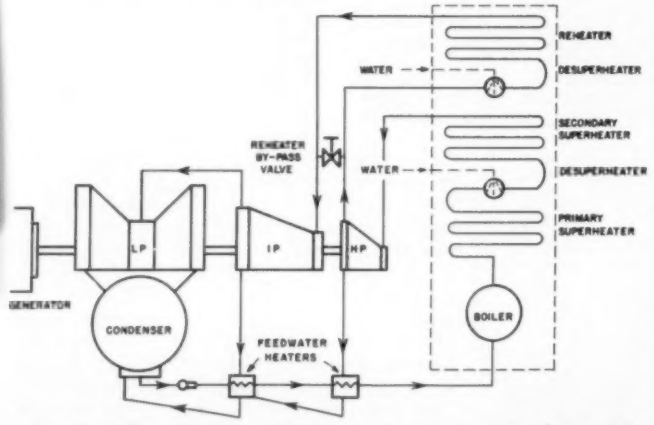

Fig. 1. Schematic diagram of a reheat boiler and turbine. Steam exhausts from the high-pressure turbine and is reheated before it passes to the intermediate-pressure turbine

In the ideal saturated-steam cycle, feedwater is heated to its saturation temperature along line AB, Fig. 2, and evaporated along line BC. At point C the dry and saturated steam is admitted to the turbine, and, in an ideal turbine, expands along the isentropic line CD. Exhaust steam is then condensed along line DA, returning to its initial point A. In this cycle the total heat added is represented by area KABCLK, where KL is drawn at absolute zero, or —459.7 F. The heat lost to the condenser circulating water is represented by area KADLK. The heat converted

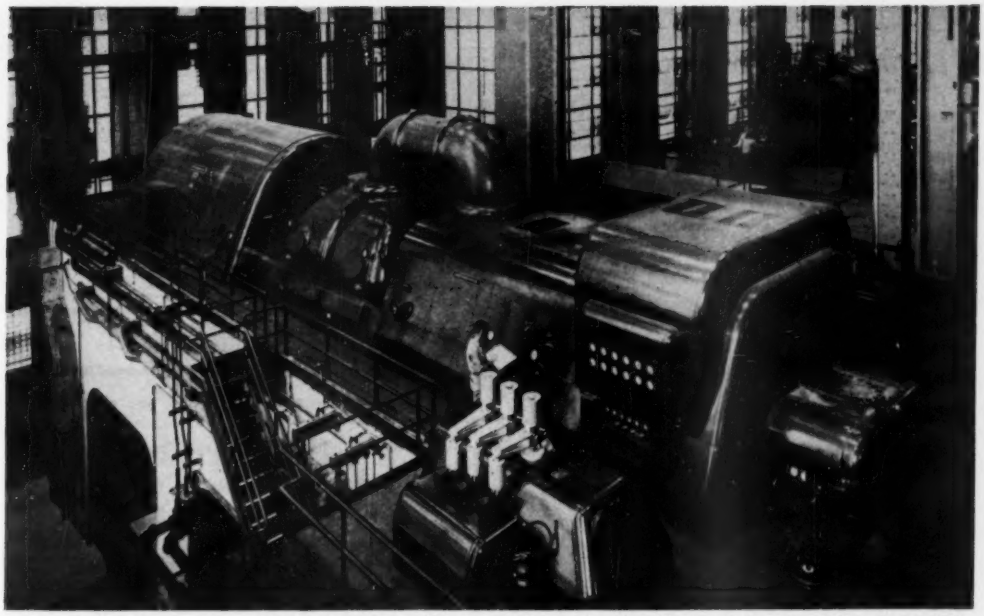

Fig. 3. This 65,000-kw, 1450-psig, 1000F/1000F reheat machine was installed in the Edgar Station of the Boston Edison Co. in 1949

into useful work, for an ideal turbine, is represented by area ABCDA. Thermal efficiency of the cycle is the ratio of the area ABCDA to the area KABCLK.

In the superheat cycle, feedwater is heated along line AB and evaporated along line BC. Then it is superheated along line CE and admitted to the turbine at point E where it expands through an ideal turbine along isentropic line EF and is condensed along line FA. The additional heat available for work due to superheat is represented by the area DCEFD and the total additional heat added is represented by area LCEML. The ratio of additional work available because of superheat to the total additional heat is higher than for the saturated steam cycle, indicating that superheating has increased the over-all efficiency. Also moisture in the low-pressure end is reduced, which adds still further to the thermal gain due to superheat.

Efficiency gains from reheating are very similar to those from superheating. The steam follows the same path as the superheat cycle to a point G in Fig. 2 where it has expanded through part of the turbine. There it exhausts to the reheater, where it is resuperheated to point H and returned to the turbine. The resuperheated steam expands along line HJ in the intermediate- and low-pressure turbines to the exhaust. The ratio of the area FGHJF to the area MGHNM is the efficiency of the reheat part of the cycle. If this efficiency exceeds the efficiency of the saturated and superheat part of the cycle there is a gain due to reheat.

Gains can be represented by the heights of rectangles equivalent to the areas of the superheat cycle and the reheat portion of the cycle. In Fig. 2, area of the superheat rectangle AOPFA is drawn equal to area of the superheat cycle ABCEFA; and area of the reheat rectangle FRSJF is drawn equal to area of the reheat portion of the cycle FGHJF.

Influence of Pressure

Gain in efficiency due to reheat varies with the pressure at which the steam is reheated. The location of point G in Fig. 2, showing temperature at which steam is returned from the turbine for reheating, is also a measure of its pressure. The higher point G appears in the chart, the greater is the reheat pressure. Increase in thermal efficiency due to reheat is plotted in Fig. 4 against reheat pressure for steam conditions of 1450 psig — 1000 F. total temperature, reheating to 1000F and with five stages of feedwater heating. The improvement includes the effect of reduction of moisture in the low-pressure end. The most efficient reheat pressure is shown to be at approximately 25 per cent of the initial pressure and the gain is fairly constant over the range of from 200 to 500 psig reheat pressure. For other steam conditions, the same general rule can be applied.

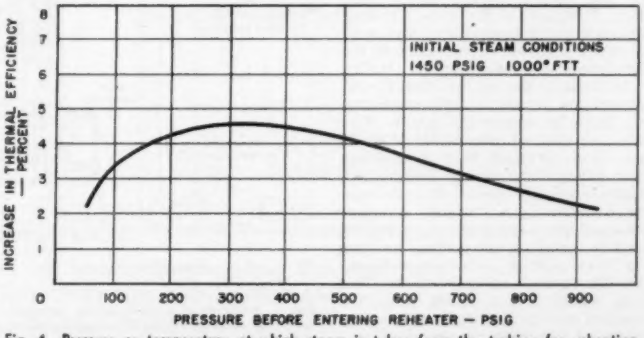

Fig. 4. Pressure or temperature at which steam is taken from the turbine for reheating determines to a great extent the increase in efficiency due to reheat. Greatest efficiency at approximately 350 psig or 25 per cent of initial 1450 psig, although this is not critical

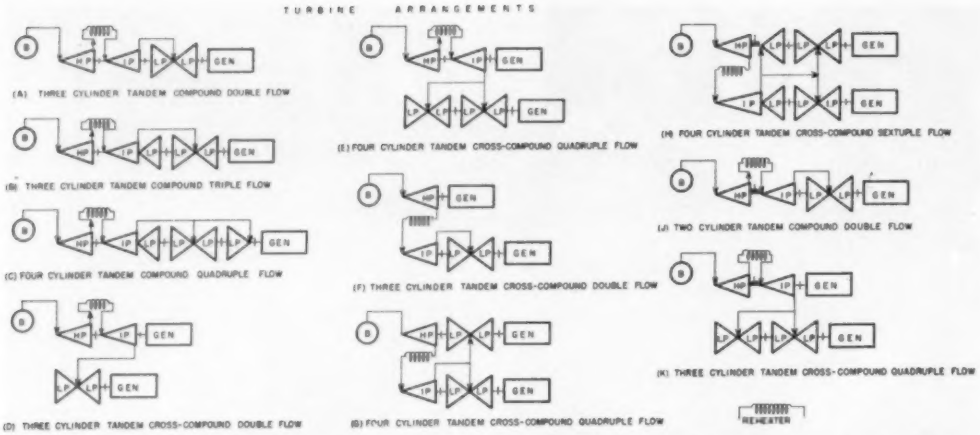
TURBINE ARRANGEMENTS
(A) THREE CYLINDER TANDEM COMPOUND DOUBLE FLOW
(B) THREE CYLINDER TANDEM COMPOUND TRIPLE FLOW
(C) FOUR CYLINDER TANDEM COMPOUND QUADRUPLE FLOW
(D) THREE CYLINDER TANDEM CROSS-COMPOUND DOUBLE FLOW
(E) FOUR CYLINDER TANDEM CROSS-COMPOUND QUADRUPLE FLOW
(F) THREE CYLINDER TANDEM CROSS-COMPOUND DOUBLE FLOW
(G) FOUR CYLINDER TANDEM CROSS-COMPOUND QUADRUPLE FLOW
(H) FOUR CYLINDER TANDEM CROSS-COMPOUND SEXTUPLE FLOW
(J) TWO CYLINDER TANDEM COMPOUND DOUBLE FLOW
(K) THREE CYLINDER TANDEM CROSS-COMPOUND QUADRUPLE FLOW
REHEATER

Fig. 5. The reheat turbine can be arranged in as many ways as non-reheat turbines. Here are ten variations that can be used

Optimum gain due to reheating to the initial temperature is between 4 and 5 per cent.

Two principal arrangements are used for combining the high-pressure and reheat elements.

1. Separate cylinders for high-pressure and reheat elements, combined with the low-pressure element in tandem or cross-compound.

2. High-pressure and reheat elements in the same cycle combined with the low pressure turbine element in tandem or cross-compound. This reduces the temperature gradient and thermal stresses over the outer cylinder.

Many arrangements of the high-pressure, reheat, and low-pressure elements are shown in Fig. 5.

Reheat Turbine Control

In Fig. 6, high-pressure steam from the boiler (shown in the upper, right-hand corner of the diagram) is superheated and passes through the throttle and steam-chest governing valves into the high-pressure turbine. It then returns and passes through the reheater, continuing back through the intercepting valve to the intermediate-pressure turbine. Progress of the steam is then through the intermediate- and low-pressure turbine elements and the condenser and back to the boiler.

In some of the earlier reheat boiler designs, it was thought necessary to have a minimum steam flow through the reheater of at least 20 per cent of rated flow to prevent the tubes from being overheated. Experience has shown that this can be avoided by a suitable arrangement of the various heating surfaces, and by tripping off certain burners by interlocking switches mounted on the turbine control valves. This has resulted in a much simplified control system, and makes the operation of a reheat power plant virtually as easy as that of plants that do not use reheat.

Governing at no load is just as steady as with a non-reheat turbine. This is probably because, at very light loads, the intermediate-pressure and low-pressure turbines do no work, and in fact act as a drag on the high-pressure turbine, so the effect of the reheater steam storage volume can be ignored. It is present practice to start the turbine with the intercepting valve wide open. Vacuum is built up as speed is increased to avoid excessive exhaust temperature.

Ordinary load changes cause no difficulty in governing. The limiting factor is the rate at which the turbine parts can accommodate themselves to the resulting temperature changes, the same as with any high-temperature turbine.

In case the generator suddenly loses its load while carrying a heavy load, the reheater and its connecting piping contain so much steam at relatively high pressure that the turbine will reach a dangerously high speed if this steam is not shut off very quickly. The intercepting valve in the reheat steam line is designed to close very rapidly and shut off steam from the reheater if the no-load speed of the governor is exceeded. The intercepting valve opens again automatically as soon as the speed falls below this value, so that operation continues normally.

If, for any reason, the turbine governor valve should fail to operate in case of excessive speed, an emergency autostop will relieve pressure on the whole hydraulic control system to close the throttle valve, the steam chest valves, and the intercepting valve before dangerous speed is attained.

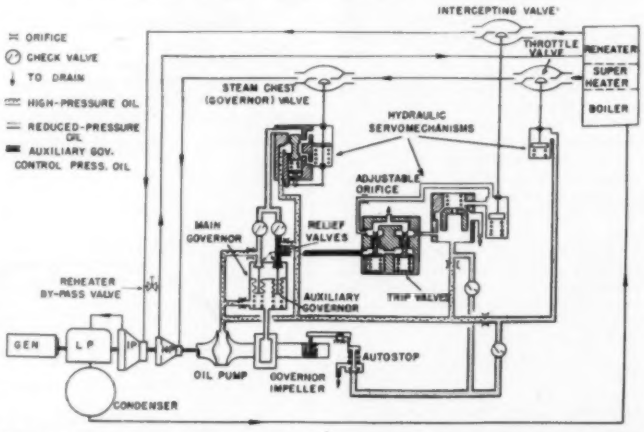

Fig. 6. Addition of a quick-acting, automatic intercepting valve on the steam line leading from the reheater to the intermediate-pressure turbine prevents overspeeding after sudden loss of load, due to the large volume of steam in the reheater. Other controls are similar to those of non-reheat turbines; and operation of reheat turbines under normal and emergency conditions is as simple and reliable as for non-reheat turbines

The PRACTICAL ENGINEER *and* ELECTRICIAN

ANDREW W. KRAMER, EDITOR

THE MECHANISM OF WEAR

As a rule one does not associate thermal phenomena with the playing of a phonograph record, yet a phonograph needle rubbing against a wax record may reach a temperature as high as 2000 degrees F, at the immediate point where the needle touches the disc. Of course the depth of this temperature is not more than a few molecules in thickness but it exists just the same.

The mechanism of wear considered from its basic aspects presents a fascinating field for investigation. When a tool cuts into metal, the tool as well as the object being machined both wear away. What the cutting tool does to the metal is intentional, but what the work does to the tool is undesired. Non-metals will wear out the hardest metals, provided we bring enough of the non-metal into frictional contact with the metal. Thus, it has been found that the stellite bushings inserted into the eyes of needles used in carpet making, wore out when 40,000 miles of flax or jute were passed through those eyes. The speed of the thread through the eyes is about 30 miles per hour.

This explains why soft coal wears out the hard steel worms on stoker conveyors and why sand wears out the impellers and casings of centrifugal pumps notwithstanding that this sand is floated in water as a vehicle. Plastics wear out some cutting tools at a tremendous rate. Wire drawing wears out extremely hard faced dies, while steam, passing through narrow passages, wears out valves and valve seats due to the ***wire drawing*** of the steam. Wire drawing due to ***blow by*** gases is also one of the greatest causes of wear of piston rings in internal combustion engines.

From a Discussion of the Mechanism of Wear by D. Landau.

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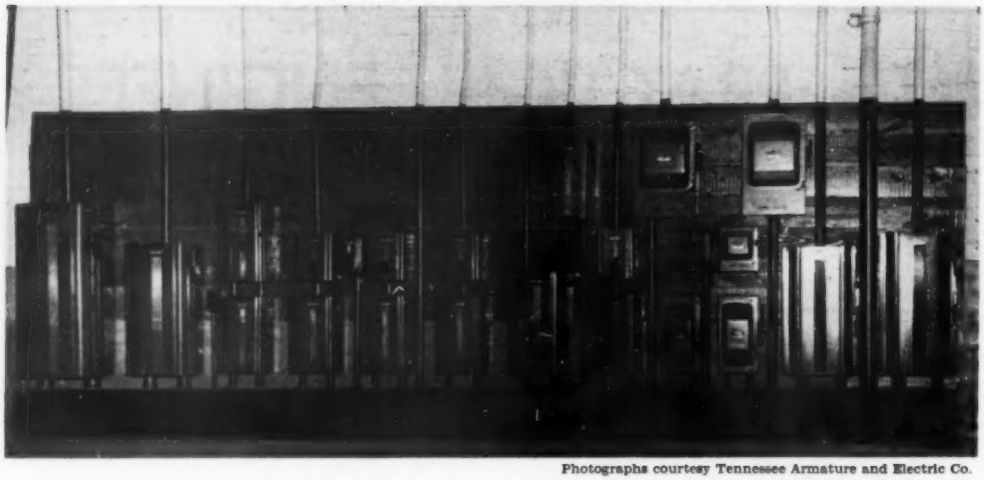


Photographs courtesy Tennessee Armature and Electric Co.

Fig. 1. THIS ENGINEER'S DREAM is just a sample of what you will find in the entire electrical system, when properly designed and constructed or modernized. All it needs now is a good stenciling job to identify circuits. It will bring smiles to insurance man, electrical inspector and fire inspector

THIS

Good Electrical Systems Make Industrial Profits

RESULTS IN THIS

By PAUL C. ZIEMKE

Fig. 2. A well-lighted shop having over-all lighting supplied by fluorescent fixtures using half white and half daylight tubes and arranged so that each row of ganged fixtures can be lighted fully for night or cloudy day operations, at two-thirds capacity for sunny days requiring a bare minimum of artificial light. Each machine has transformer for point-of-operation lamp at each position

DIRECT RELATION between maximum industrial production at lowest cost and the quality of the electric power and lighting system of a plant is well recognized by most industrial managements. During the last war, modernization and upkeep of existing plant electrical systems often had to be deferred or done on an emergency basis with substitute materials. After the war, considerable modernization was undertaken in many plants, yet it is surprising to note the number of plants where modernization of the power and lighting circuits is still badly needed.

How Poor Electrical System Cuts Profits

Not only must high production be maintained from now on, and even increased but, because of rising costs, it is necessary to eliminate a great many serious hidden costs in production that become progressively worse as the loads increase or the equipment deteriorates.

Many plants use 230-v lighting, the convenient voltage for the motor circuits, and the resulting inefficiency becomes quite marked through unbalanced 3-phase motor circuits while the line drop or low voltage troubles usually reduce lighting efficiency greatly. Where the neutral is grounded, much dependence is placed on the ability of water pipes to carry the line current. Lighting mains are often tapped to motor circuits and the resulting fluctuations in lamp performance are both nerve wracking and destructive to speed and precision of operation. These often depend on how accurately the operators may focus their eyes and use their hands in making adjustments.

While trouble in the motor circuits is usually the first to be remedied because its effects on machine out-

TABLE I—Good Seeing Solves These Major Textile Mill Problems

A. In picking department, speed and efficiency of machine adjustments are required.
B. Card fixers repair, clean, adjust and check cards while operators supply picker laps and reunite breaks in web or sliver.
C. Speedy restoration of runouts and breaks in drawing frames required. Employees must speedily find breaks of individual strands of slivers. Top-of-frame illumination must be adequate.
D. In slubbing, machine must be shut down for piecing out a broken end. If break is speedily caught, it will not carry with it several other ends. Most slubbing units not equipped with automatic controls, and this necessitates very accurate visual checks to catch breaks, mend them, and keep bobbins in creel from spinning out.
E. Spooling or winding require a high level of illumination, lest concentration produce eye strain and failure to locate loose ends of broken yarn.
F. While warping operation shuts down upon a breakage, the break must be speedily found on the section beam and tied before production suffers.
G. In slashing, thousands of fine yarn strands, running swiftly, tax eyesight of attendant in break repairs, and keeping comb aligned truly for winding upon loom beams. This machine has multiplicity of hard-to-get-at adjustments, often found only with aid of flash lamp, which is always awkward and slow at best.
H. Most unrelenting visual acuity and accuracy are required in the drawing-in operation.
I. In weaving on looms, cleaning, oiling and adjustments or creeling make the weave room a place of intensive eye concentration.
J. Final grading and inspections require work of experts to catch defects in finished goods lest they get out to critical buyer.

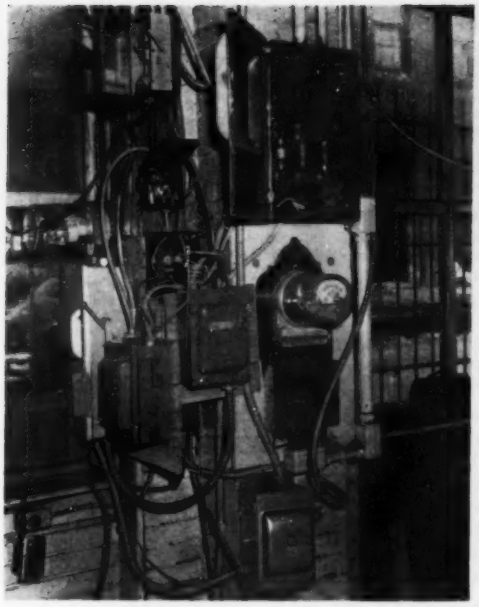


Fig. 4. In the plant that puts up with the rat's nest, you'll probably find at least one unfortunate chap like this trying desperately to see the details of his work. Point of operation lighting would be a godsend to him. Power at 460-v at the lathe motors may be stepped down to 120 volts for extension lamp and appliance use by a 1-kva dry transformer to save expensive lines to 120-v distribution panel

THIS

THIS RESULTS IN

Fig. 3. Left—This "rat's nest" obviously grew like Topsy, without planning, until it reached the stage where physical troubles and costs reach a prohibitive level. If the engineer grew with it, he probably understands it; but pity the man who has to take over

put are instantly apparent, not enough attention has been given to lighting in many plants despite the tremendous amount of promotional work to improve lighting by the various electrical manufacturers and the power utilities.

Of all industries, the textile industry is one of the best examples of the intimate relation between lighting efficiency and high production at low cost. A number of the specific operations in the textile mill, directly depending on the seeing ability of the workmen, are shown in Table I.

Some idea of the lethargy with which the lighting problem has been approached by all too many managers and owners is shown in a recent U. S. Government report. This indicates that of 24,443 industrial plants in operation, the average age of the lighting equipment is 5.4 years and these installations have an average intensity of about 7.5 ft candles. To bring these lighting conditions up to the values recommended by eye especialists would necessitate an additional 108.2 candle feet in intensity.

Remodeling Lighting

Nowadays, with alternating current almost universally available, we have the cool, efficient and decorative fluorescent lamp, adaptable to almost any installation. The reduced drain of these lamps on the electrical wiring system often makes it possible to use existing circuits, provided they were well constructed in strict compliance with code requirements. In many cases, the engineer can replace circuits now overloaded by using the new plastic-coated wiring with reduced external diameters, permitting larger wires in the same conduit runs.

A detailed survey of the load requirements and characteristics can

Table II—Wire Sizes for Use in Figuring Correct Conduit Sizes for Combinations of Bare and Insulated Wire

Wire Size	Type	Total Area, Sq. In.	Carrying Capacity, Amperes
8	solid	0.013	50
6	stranded	0.0263	70
4	stranded	0.0419	90
2	stranded	0.0665	125
1	19x0.066	0.0855	150
0	19x0.075	0.109	200
00	19x0.084	0.137	225
000	19x0.094	0.173	275
0000	19x0.106	0.219	325
Circular Mils			
250,000	37x0.082	0.259	350
300,000	37x0.090	0.309	400
350,000	37x0.097	0.364	450
400,000	37x0.104	0.414	500
450,000	37x0.110	0.467	550
500,000	37x0.116	0.518	600
600,000	61x0.099	0.624	680
750,000	61x0.110	0.785	800
1,000,000	61x0.128	1.04	1060
1,250,000	91x0.117	1.29	1180
1,500,000	91x0.128	1.58	1360
1,750,000	127x0.116	1.89	1515
2,000,000	127x0.125	2.07	1670

Fig. 5. Rigid conduit for good appearance, long life, dependable grounding, replaces old war emergency wiring. Reduced fire insurance premiums will pay for installation in two years.

Fig. 6. Inspector catches "bootleg" job to be replaced with code-approved fittings. Note lack of connection to ground, since green wire is not wired straight through at splice held in inspector's hand and no ground clip provided at attachment plug, as required where non-polarized, non-grounding receptacles are part of equipment. Here is danger of electrocution and fire

well be made by the plant's power and electrical staff to determine what modernization is needed. It will require uninterrupted time to do the project thoroughly and without distractions. Of course, if power is purchased, local utility engineers can be of much help in this survey.

It is usually the plant with increasing or changing load conditions that manages to get pretty badly out of hand. In surveying these, it is necessary to analyze the average load, the total connected load, the maximum load, the energy load, the friction load and the various load losses to reach a fair evaluation. It is customary to begin at the generator or substation and work out towards the last motor and lighting cabinet.

Instruments needed will be voltmeter, ammeter, two split-core current transformers, one 3-ratio current transformer, and a megger for insulation testing. If the layout is modern, it will include a totalizing meter and associated equipment for the peace of mind and friendly relations of customer and power company. Or perhaps two meters, one each for customer and power company, and both compared with a standard meter at suitable intervals.

Where's the Power Being Lost?

A well-planned survey should show how and where the power is being used, whether output is in keeping with the power costs and whether maintenance labor and material are in suitable proportion to total equipment and production. The latter is an effective check on old, obsolete or, what may be even worse, overloaded but high-class equipment. In contrast, there may be serious underloads where once-heavily-loaded drives are being spun needlessly by too much horsepower.

Total of nameplate ratings of motors is the connected load, while the maximum load is the highest imposed on the transmission line, transformers and switches at any given period, for example, 10 min. Average load is that consumed by all the equipment for a stated period—day, week, month or year. Useful or energy load is that part of the total load from which some benefit is derived. Lastly, friction load includes all losses in transmission lines, bearing friction losses and windage in motors.

Lagging power factor is the silent thief. Its cause is underloaded induction motors, multiplicity of transformers, transformer type welders and other induction equipment. It shows up in overheated motor windings, cables and transformers. Prime drives should be powered by synchronous motors, or capacitors should be installed, either or both providing power factor correction.

Finally, there is the possibility that the plant is paying high demand rates for current not used because of a low load factor. This might occur if the plant does not use the power supplied at the cheapest rate steps or permits an excess over the maximum demand when it is being purchased on the demand basis.

New Circuits in Existing Conduits

In remodeling his electrical system, the engineer may take advantage of the new features of the Electrical Code, rules 402-D and 404-D, which permit him to use existing conduits for greatly-increased loads where bare neutrals are pulled in to conserve space. Combined areas of bare and insulated conductors are computed under the 40 per cent area rule. Table II shows correct sizes where combinations of bare and insulated wires are to be employed. The voids, or spaces between the wires making up the individual stranded conductors, are included in Table II.

The Vortex Tube Today

In the June issue of Power Engineering, among other things there was a brief reference to the Hilsch Tube. The interesting behavior of the Hilsch or Vortex tube was described as well as its principle of operation. As a result of the publication of this brief comment on the Vortex tube, Roy MacGee, Jr. presents this article which discusses the vortex tube at greater length and also Mr. MacGee's own experimental work with this tube at Boston University. Mr. MacGee majored in physics and the vortex tube was the subject of his thesis for his M.A. degree in the early part of this year

By ROY C. MacGEE, Jr.

ON DECEMBER 12, 1931, George Joseph Ranque of Montlucon, France, applied for a French patent on the vortex tube. This invention was a device that separated a stream of compressed air into two streams of air, one hot and one cold. Figure 1 shows a modern model of this device.

The principle of the device is very simple in that it requires no moving parts. The compressed air is led into a nozzle that is placed on a tangent of the tube. The high velocity of the air through the nozzle causes a vortex or whirlpool as it centers the edge of the tube. The center of the vortex is forced out the small hole near the nozzle by the throttling of the air at the opposite end of the tube.

Ranque obtained a United States patent on March 27, 1934. After the presentation of a brief paper to the Societe Francaise de Physique in Paris the device lay uninvestigated until its rediscovery by a German physicist, Rudolf Hilsch.

Hilsch used the vortex tube in his low temperature research. Dr. Robert Milton of Johns Hopkins, while with an American scientific team working for the Bureau of Standards in Germany, obtained a model of the vortex tube that he brought to this country. Dr. Milton discussed the vortex tube at a meeting of the American Chemical Society in April, 1946.

Since then many papers, articles and theses have been written on the vortex tube. Industries, schools and independent investigators have been and still are working on various phases of this interesting tube. Investigations vary from highly theo-

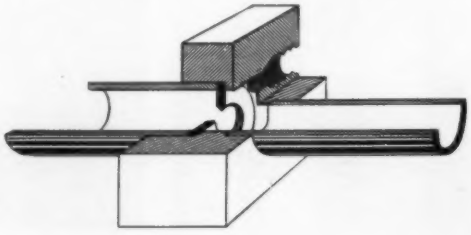


Fig. 1. Cross-section through modern type of Uniflow Vortex Tube

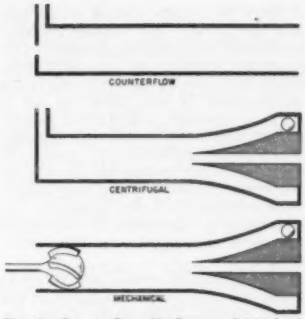


Fig. 2. Counterflow, Uniflow, and Mechanical Vortex Tubes

retical mathematical theses at the Massachusetts Institute of Technology to a design for a homemade vortex tube appearing in Popular Science magazine. Although much work has been done, much more is needed before all the secrets of this tube can be found.

Ranque described three types of vortex tubes, the counterflow, uniflow, and mechanical tubes. Figure 2 shows these three basic types.

The counterflow type has been described in the preceding portion of this article and a sketch of a working model of this type is shown on Figure 1.

The uniflow vortex tube varies from the counterflow tube only in its method of separation. While the counterflow requires a reversal of the flow of air, this reversal is not needed in the uniflow tube. Figure 2 shows the center of the vortex being separated from the outer portion by means of a knife edged orifice. The outer portion of the vortex is carried to a manifold where it is collected and removed.

The mechanical type of vortex tube varies from the uniflow vortex tube only in the method of creating the vortex. While the uniflow method uses the velocity of air stream aimed on the edge of the tube to cause the vortex the mechanical tube uses a power supplied rotor.

Most of research has been done on the counterflow type of tube. After investigation of this type tube the writer feels that more investigation should center on the uniflow type. It is possible that the flow principle will be simpler and the efficiency might be better. This is expected because there is not as much mixing of the hot and cold streams in the uniflow vortex tube.

The writer's investigation was on a counterflow type of vortex tube. This tube was constructed of clear plexiglas so that the flow pattern of the air could be seen. Figure 3 shows the tube operating with a colored water trace injected into the inlet air. The trace shows the configuration of the air as it progresses down the hot tube. The vortex is seen to increase in pitch as the hot tube valve is approached.

Figure 4 shows the action of the air in the cold tube. The air in the cold tube is seen to move in a helical motion in the opposite direction as

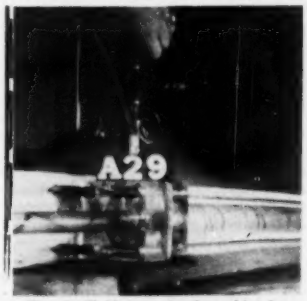


Fig. 4. Fluid trace in the cold tube

the vortex of air in the hot tube. This photograph shows that the reversal of air flow passing from the cold tube is given the same rotation as the air moving in the hot tube.

Figure 5 shows the nozzle pattern for a vortex tube having four nozzles. Tests by the writer show that four nozzles are sufficient for the centering of the vortex at the nozzle.

The vortex tube has been relatively unsuccessful in the displacement of modern refrigerating systems due to its low efficiency. The United States Government is still investigating the mystery of the tube. The research scientists of Project Cumulus have found the tube useful as an

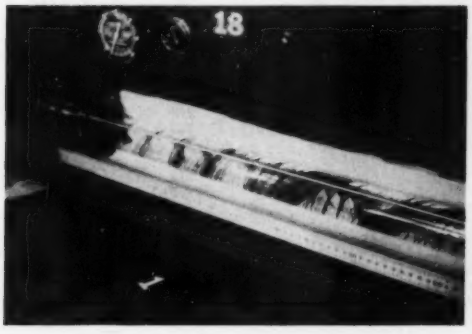


Fig. 3. Counterflow Vortex Tube operating with a colored water trace in the inlet air

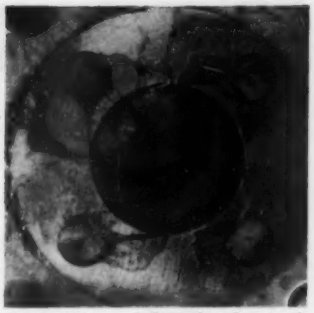


Fig. 5. Pattern of flow of a four nozzle Uniflow Vortex Tube

ambient temperature indicator for fast aeroplanes. Recently government scientists have made an analysis on the use of the vortex tube as a cooling device for the cabins of supersonic aeroplanes.

Some other fields have found a use for the tube but it is still more or less a laboratory toy. There are undoubtedly many places that the tube would prove useful, but they still lie undiscovered.

The attractive elements of the vortex tube are its simplicity and its ease in manufacture. Temperatures of 30° F. and lower are easily obtainable. Inlet air pressures vary from 100 psi to 200 psi, when the cold outlet is at atmospheric pressure. These temperatures are obtainable almost instantaneously since no warmup period is required. The main drawback of the vortex tube is in the poor efficiency. However, the tube must have applications for intermittent service that have not been demonstrated to date.

THE STEEL COMPANIES of the United States, with their present record high capacity, can provide 2240 lb of steel for every 2000 lb needed when World War II was at its height, American Iron and Steel Institute said recently. In 1952 that figure will be raised to 2360 lb as a result of the further expansion and improvement programs of steel companies.

Every day, the finished steel made from 24 hours of full output of ingots and castings will provide steel for all the following items (average sizes): An aircraft carrier, 500 airplanes, 1000 anti-aircraft guns, 500 tanks, half a million 3-inch shells, 1000 howitzers, 200 aerial bombs, two heavy cruisers, 1000 freight cars, 2000 trucks, two cargo ships, two tankers, 12,000 autos, 2000 homes, 20,000 household refrigerators and 20,000 stoves. And after all that, more than 20,000 tons of steel would remain for other purposes.

The steel industry, with a record high annual capacity of 100,563,500 tons as of July 1, 1950, will have a capacity of nearly 106,000,000 tons by the end of 1952, as the result of the current expansion programs.

THE PRACTICAL ENGINEER AND ELECTRICIAN

Preheating of Fuel Oils

Reasons for preheating . . . Atomization—What it is . . . Which oils should be preheated . . . Requirements for preheating . . . Atomizing temperatures . . . Flash point . . . Preheating according to gravity . . . Excessive preheating . . . Too low preheating

By PAUL F. SCHMIDT
Allied Oil Company, Inc., Cleveland, Ohio

THE PREHEATING of heavy fuel oils has always been a hit and miss affair. Some operators preheat too much, while some not enough. A lot of operators are of the opinion that the main purpose of preheating is to liquify the oil, so as to make it more pumpable, therefore any temperature is good enough. It should be remembered that the proper preheating temperature has a great deal to do with correct and efficient combustion, with resulting high heat release, fuel conservation, and economy of operation. Incorrect preheating can give poor combustion, resulting in smoke, carbon formation and fuel waste.

Reason For Preheating

The combustion of fuel oils is a chemical reaction, in which oxygen from the air combines with the oil. As in most chemical reactions an increase in temperature will aid the reaction, sometimes to start it and often to help its completion. This same theory also affects the proper burning of fuel oils, and is accomplished by preheating the oil, which brings it closer to the oil's ignition point, and also thins out the oil for better atomization.

What Is Atomization?

It is impossible to ignite the oil properly in the solid fluid state, so the burner breaks it into a fine spray, and this action is commonly called atomization. This atomization is accomplished at the burner tip, or just beyond it, by air, steam pressure, and in mechanical burners by the oil pressure itself. Now, if the oil was not heated and thinned out, it would be extremely difficult to obtain this fine spray, thus giving poor ignition and combustion. Production of this fine spray makes it possible for more oxygen to react with the extremely small oil particles, to produce a rapid and complete combustion.

Oils of grade No. 2 are never preheated, due to their low viscosity. No. 4 oils are occasionally preheated, but not as a general rule. No. 5 and 6 oils are the ones that require preheating, as their viscosities are high.

Requirements For Preheating

In this article, preheating and atomizing temperatures refer to the same thing. In order to preheat any oil properly so as to obtain correct atomization, there are three characteristics that must be known:

1. Viscosity of the fuel oil
2. Proper atomizing temperature
3. Flash point, closed cup

As fuel oils have a great variety of viscosities, it is not always possible to purchase or receive oils of constant viscosity. Though you may order and specify a certain viscosity, it does not mean that is what you are delivered. The supplier should supply an oil that has a constant and uniform viscosity to the consumer, otherwise the consumer's efficiency is lowered. If one time the oil is light in viscosity, next time heavy, the burner and pressure adjustments will not be correctly set, moreover the preheating temperatures will be incorrect. Unfortunately, few industrial companies have facilities for determining viscosities, so they must rely upon the supplier for this information.

As previously mentioned, the viscosity will decrease or thin out as the oil is heated. The more heat, the lower the viscosity, and this physical property is used advantageously to bring the viscosity or fluidity of the oil to the proper consistency for good atomization. It is therefore essential to know the viscosity of the oil being burned, so as to determine the proper preheating temperature.

Atomization Temperatures

For good combustion, engineers usually set a certain viscosity which the oil must have to obtain the best atomization. As most No. 5 and 6 oils have a high viscosity, the preheating temperature brings the viscosity to this optimum point for correct and proper atomizing. This viscosity varies among combustion engineers, ranging from 100 to 200 sec, Saybold Universal, and while 150 sec is the one most generally used, the others are also included in the table. This table will show the temperature to which you must heat the oil to obtain the correct viscosity for atomizing and combustion.

The type of burner and method

Atomizing Temperatures for Various Viscosities

Viscosity at 122 F SSF	Viscosity at 100 F SSU	Atomizing Temp to obtain visc. of 100 SSU	Atomizing Temp to obtain visc. of 150 SSU	Atomizing Temp to obtain visc. of 200 SSU
	100	100	80	70
	150	120	100	90
	200	135	110	100
21	300	150	128	115
26	400	160	138	128
30	500	170	145	133
39	750	185	160	147
50	1000	190	168	155
60	1200	200	175	160
75	1500	205	180	168
100	2000	215	190	175
115	2500	220	195	182
135	3000	225	200	187
145	3500	229	205	190
160	4000	235	208	194
170	4500	237	212	197
190	5000	240	215	200
200	5500	245	218	204
220	6000	248	220	208
260	7000	250	225	210
285	8000	254	227	214
320	9000	258	230	216
342	10000	260	235	218

of atomizing will also have some bearing upon the preheating temperature. If steam atomization is employed with inside mixing, a lower temperature may be used, as heat will be received from the steam in the mixing chamber.

If air is used for atomizing, the oil must be preheated higher, as the air will cool the oil. With mechanical burners, the oil must be lower in viscosity, thereby requiring a higher preheating temperature.

Flash Point

Some operators claim that they always preheat the oil to just below the flash point. This is not too good a practice, as the viscosity can be high, necessitating higher preheating temperatures. If the oil were preheated to just below the flash point, it would be insufficient to reduce the viscosity enough.

If the flash point is low and the preheating temperature is high, there may be danger of preignition, as the temperature will drive off too many of the light vapors, causing a gas to form which can cause the burner to puff and pulsate. If this happens, the preheating temperature should be decreased, if possible.

Preheating According to Gravity

In the past, many operators have used the gravity as an index for preheating. This method was a satisfactory method in those days, when the type of oils were few and uniform, but today with modern refining processes and many variations in fuel oils, this index for preheating is useless. The preheating temperature for a certain gravity oil may be correct in one case, but unsatisfactory for another oil of identical gravity because of difference in viscosity.

Excessive Preheating

Preheating temperatures must not be excessive. If too great a heating is used, there is danger of cracking and coking the oil in the preheater, causing blocked burners and loss of heat. What happens in this case is principally the same as in the cracking of oil during the thermal cracking process. Due to the excessive temperature in the preheater, the oil is broken into a heavy oil, or tar, and light vapors. These vapors pass through the preheater and burn, but as they are very light, they also have little heat. The heavy cracked oil may block the preheater, or as it is usually extremely heavy and viscous, it may block and carbon the burner tips. This specific trouble is not common, but it has happened to operators who should know better.

If an oil is preheated too high, it can become too fluid, thereby going through the burners too fast, giving improper combustion, and carbonization on the combustion chamber walls, as well as slipping at the pump, vaporization and pulsation.

Too Low Preheating

If the preheating temperature is too low, many of the same difficulties will arise as with too much heat. As the viscosity will be too high for good atomization, inefficient combustion will be obtained, resulting in high fuel consumption, loss of heat, smoke and carbonization.

Sometimes it is not possible to start the burner due to the inability of obtaining the fine spray or atomization necessary to promote combustion or burning.

As the oil temperature is low, it is therefore further away from its flash point, making starting more difficult.

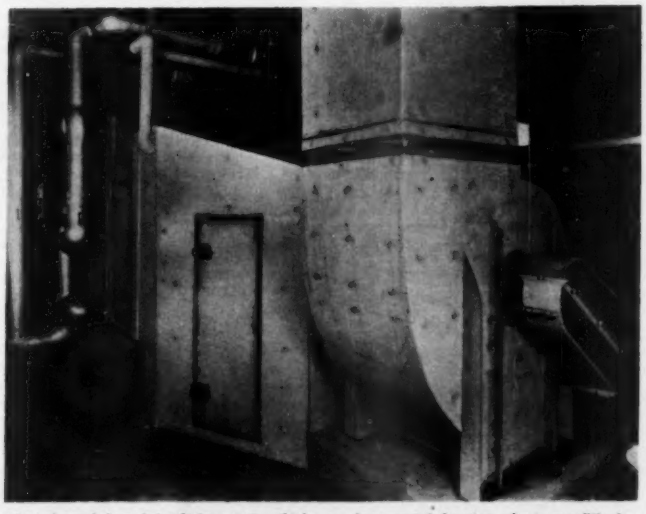
Insulation of Complete Air Conditioning Unit Saves Time and Materials

METHOD of applying mineral wool board insulation to an air conditioning unit recently enabled the William Penn Hotel, Pittsburgh, to eliminate several time-and-material-consuming steps normally required to insulate such equipment. The technique is used to apply mineral wool to sheet-metal enclosing five stages of air conditioning, a circulating fan, and distribution ducting. It includes three basic steps: application of (1) special clips and (2) mineral wool board sections and (3) two coats of paint. Commonly specified materials such as wire mesh, insulating cement, and finishing cement are not required.

At the William Penn, five conditioning stages housed in one large sheet-metal enclosure produce clean air at the proper temperature and humidity. The five stages are: (1) preheating to 80 F by steam coils, (2) cleaning by an electric air filter, (3) cleaning by a secondary filter, (4) cooling to approximately 55 F by chilled water coils, and (5) heating to 70 F and drying by steam tempering coils. It is to maintain these process temperatures that 1-in.-thick mineral wool board insulation is applied to the sheet-metal enclosure. Further, by preventing air, either during treatment or distribution, from absorbing excessive heat from the surrounding room atmosphere, the insulation results in reduced load on the power system because extra energy is not required to combat ambient heating.

The special clips which secure the insulation to the surfaces of housing, fan and duct are attached to the sheet-metal by an adhesive. Each clip consists of a 1½-in.-square metal plate, punctured with small holes, and a length of heavy-gage wire welded perpendicularly to the metal plate at its center. The punctured metal plates are pressed into the adhesive on 12-in. centers and, when the adhesive dries, each clip is designed to withstand a tensile stress of more than 100 psi.

Mineral wool board insulation in 24 by 48-in. sections is then impaled on the wires of the clips with all



Mineral wool board insulation, 1 in. thick, on sheet metal housing of air conditioning equipment at William Penn Hotel, Pittsburgh

edges carefully butted together. To secure the insulation, a lock-washer is tightly set on each protruding wire. The ends of the wires are then clipped at the washers. Insulation corners and joints, and the tops of the washers are covered with 10-lb asbestos paper carefully secured in place with cold-water paste. To complete the insulation, two coats of paint are applied to all insulated surfaces.

The insulation, thus installed, assures that proper temperature is maintained as air is conditioned and distributed to the dining rooms, lobby and cocktail lounges of the William Penn Hotel. Power costs are kept low by eliminating both excessive loss of heat from the two sets of steam coils and unnecessary heating of the chilled water in the fourth stage of the conditioning system.

The box shape of the enclosure further promotes low installation cost because only one form of insulation—mineral wool board—is applied to regular, flat surfaces which generally can be insulated in the least time. Straps, bands and cement, often necessary for insulating round or irregular surfaces, are not required.

Four doors on the side of the insulated housing allow maintenance men ready access to all stages of the air-conditioning system. For example, a maintenance man entering the third door from the right may reach the third stage and change the secondary air filter. The insulated pipes entering the side of the housing are the supply and return lines for steam in the first and last air conditioning stages and for chilled water (large-diameter pipes) in the fourth stage. The arrows on the pipes indicate the direction of flow of the chill water and steam.

Although applied here to a hotel air conditioning system, the step-saving and cost-cutting technique can be applied with equal advantages to systems in office buildings, schools, hospitals, theaters, and industrial plants.

Induction Heating

Notes on Induction Heating from *Tempil Topics* with added illustrations showing typical induction heating set-ups and the effect of induction heating

INDUCTION heating should not be confused with dielectric heating. In *dielectric heating*, the workpiece, which must be non-conducting (wood, paper, rubber, ceramics, etc.) is held between two plates which serve as electrode., for an alternating current of frequencies between one million and fifty million cycles per second. This rapidly alternating electric field produces molecular (dipole) oscillations in the substance, and the resultant internal friction causes the workpiece to heat up rapidly and uniformly throughout. *Induction heating*, on the other hand, depends on a transformer effect. The workpiece, which must be a conductor of electricity, although it need not be a good one, is surrounded by a conducting coil which forms the primary and carries alternating or pulsating current whose frequency may range from 60 to 1,000,000 c.p.s. A typical arrangement is shown in Fig. 2. The workpiece itself forms the secondary of the transformer, and currents are induced in its surface layer. These are converted to heat energy by the resistance of the metal.

The rate of heating by the induction . method understandably increases with increase in the supplied power. As the frequency of the current is increased, the depth of heat penetration decreases. The size of the workpiece to be heated, the desired rate of heating and the required depth of heat penetration therefore largely determine the choice of current source. Commercially available equipment for providing alternating current of the proper characteristics includes motor-generator sets, vacuum-tube oscillators, mercury-arc converters and spark-gap converters.

Heat can be produced so rapidly by the induction method that it can be localized to the desired portion of the workpiece without appreciably affecting the rest of the work. Where only a relatively small part of a larger object need be heated,

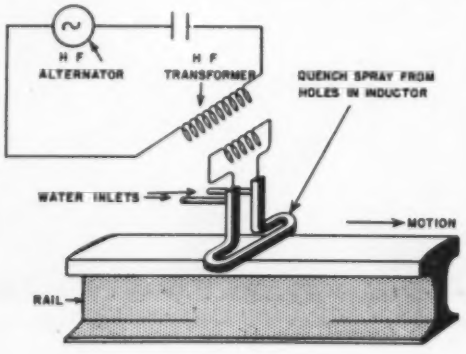


Fig. 1. Arrangement for the surface hardening of steel rail by induction heating

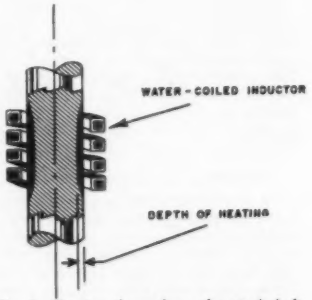


Fig. 2. Showing the surface of a steel shaft that is heated (and hardened) by passing it through a water-cooled inductor

there are obvious economies and speeding of production. Dimensional and metallurgical changes are minimized and the dangers of surface oxidation, scaling and decarburization are reduced.

Production line brazing and soldering operations lend themselves excellently to induction heating. Bonding is carried out at high speeds, especially in soldering operations, in which filler metals melting below 700 F are utilized. For brazing by induction, the silver alloys will produce joints with strengths up to 100,000 psi at high production rates and can be used to join dissimilar as well as similar metals.

Induction heating permits selective hardening of a restricted portion of a larger piece on a production basis. Small pieces can, of course, be heated over all. The shape of the object may be irregular provided a coil can be designed for uniform application of heat. The operation is further limited to materials such as plain carbon steels, cast iron, the hardenable stainless steels and other alloy steels which may be treated by heating to above their critical temperatures followed by rapid cooling. Suitable auxiliary equipment is required to provide for movement of

the heat treated piece and for the air, gas or liquid type of cooling used. While steels containing as little as 0.15% carbon may be hardened, those containing about 0.50% carbon are commonly used, with hardnesses resulting up to 60 Rockwell C. By interrupting the quench so that residual heat remains in the workpiece, tempering effects may be obtained.

For surface hardening, in addition to the advantages cited, induction heating permits precise control of depth and temperature of the heated layer.

In many forging operations induction heating enables high production rates to be maintained with resultant savings in equipment and manufacturing space. A minimum of scale formation due to rapid heating gives considerably increased die life. Decarburization of the workpiece is also reduced.

Induction heating has found application in the local preheating and stress relieving of welded joints in simple and air hardening steels. It is of particular value in the field erection of large pressure vessels for the petroleum and chemical industries.

A number of other uses to which induction heating has been put in the arts and industries include: straightening of shafts or other cylindrical objects with proper control of temperature to avoid detrimental effects on the properties of the part; shrink fitting of one metal part over another by means of rapid local heating, usually at 500 to 600 F; melting of small metal batches where costs are secondary to freedom from contamination during the melting process; heating compacts for sintering in powder metallurgy; and manufacture of precious metal clad objects.

FOR THE PUMP OPERATOR

PUMPS AND GALOSHES

By BERT RICHARDS
Christie Street Hospital
Toronto, Canada

PLUNGER PUMPS are very weak sisters in handling sludgy liquids. By their nature and design there is a dead position, without force, at the end of each stroke, during which valves and checks must seat. Any foreign matter or sediment caught under them will kill jump efficiency. Even in dealing with condensate returns of supposedly pure distilled water, bits of rust or scale squeezed instantaneously between disc and seat may easily lead you into dismantling the whole valve chest too often for convenience. Rotaries with flat or inclined flap checks would seem best adapted for such duties; the checks are often hinged rather loosely so that the disc can play around some, and contact surfaces will then wear evenly instead of grooving.

Sump pumps require more careful attention than is commonly accorded them. Float operated at low head to take care of seasonal or periodic drainage, if one fails for even a few hours it may mean replacement of pipe-covering, damaged motors, and a messy cleanup. It is always a moot question whether such non-steam equipment should be the engineer's baby or that of maintenance foreman, both arrangements are in use on different premises and seem fairly satisfactory, but the very first emphatic MUST is a well defined and understood division of responsibility for these services; otherwise there may develop some buckpassing and even neglect.

Maintenance and their friends had plenty fish

Certain plant locations are too low for proper flow level, having to pump their sewage. This, you may take from me without salt, is one collosal headache. From banana peel to rubber prophylactics, from rags to razor blades, everything is there. Take the pump cover off and marvel at a perfect collection agency. Note the intensity of effluvia which would grow mushrooms on the air alone. Strainer gates have cleaning rakes attached to stop larger timbers and aeroplane tires from going through; they ignore quite plenty. Cleaning a clogged sewage pump is a dirty, sickening and dangerous job that I wouldn't ask my staff to do on a bet. Men specially outfitted with rubber coveralls, gloves, hood-mask, respirator, and hipboots should do this work and be paid commensurately. Danger of serious infection squarely faces staff members who foolishly undertake the job without proper clothes and protective devices. It is far too big a hazard.

I still smile on occasion over one plant which maintained a little pump station way down at lake level. Besides ordinary city supply for human use, they needed huge quantities of water in textile manufacture, washing, leaching, bleaching, etc. Maintenance men and engineers used to give a casual look-see at happy haphazard intervals; no one worried so long as the water was there. One night the bleach foreman reported no water. Shift engineer with a flashlight found pump not working. Electricians couldn't get the motor going. So next day maintenance men were sent down, and came back with bulging optics, (not to the power plant) saying that the whole well was jammed tight with fish! The inlet screen had collapsed on occasion of a piscatorial convention and everyone was there from alligators to turtles. Maintenance men and their friends had plenty fish—and then we got a plaintive squawk from the powerplant . . . "Maintenance had no business to clear out that pit, it's the engineers' job!" Whadya know? A somewhat discordant note from the usual tune, by golly. They might as well claim sewer cleaning for the chewinggum and nickels salvage! Anyway they asked for—and got—the pump pit as a prize pet, sans fish.

HINTS ON PUMP MAINTENANCE

By W. B. KENNEDY

WHEN the cup leathers in certain types of pumps wear out too quickly, it usually means the piston rod is not "centered" in the cylinder. (This statement also applies to the air-pump piston rod.) When the piston rods are off center, the cup leathers do not wear regularly, but usually wear out to one's right or left when facing one side of the walking beam. This is caused by failure of the piston rods to center the cylinders; they are off center at the walking-beam end, and it is here that the correction must be made. (This trouble is usually referred to as "cutting" out instead of wearing out.) A characteristic of this type of trouble is that the cup leathers always wear more, or faster, at one point than at the opposite point. While it may occur at one's right or left when facing the end of the walking beam, instead of the side as referred to above; the

cause of the trouble is still located at the walking beam end of the piston rods, caused by "off-centeredness."

When this trouble occurs in a new pump, the cause is a defect in the shape of the walking beam, or the casting to which the piston rods are attached; or if these castings are properly shaped, they are misaligned at the "joints" for some reason. I don't know how such defects in manufacture creep in, but occasionally they do, and, although a batch of pumps may all look alike, they don't all function perfectly in practical, everyday use.

The remedy is to center the piston rods with the cylinders, from one end to the other, even if it requires new castings, new bushings, or a general re-working. To avoid misunderstanding, I don't attach any importance to any effort to correct such troubles by merely trying to center the piston rods at the "piston" end, because I have never seen a piston with the rod hole off center.

This type of trouble can cause noise, as well as excess and rapid wear; but when a pump has, or develops, a distinct "knock" (once for each revolution of the crank gear) it may be caused by too long a pump rod, causing the piston to strike the valves in the lower end. When wooden pump rods are put in full length while dry, they may swell as they absorb water, producing considerable increase in length. The position of the connecting rods and crank pins at the exact moment the knock occurs should indicate whether it is caused by excess length in the pump rod.

When it has been definitely determined that the pump rod is not the cause of a knock, check moving parts for misalignment or wear. Worn bushings should be replaced without delay. It is usually a good rule to replace ALL bushings (if worn enough to produce noise, misalignment, or undesirable slack in parts) rather than a single worn bushing, because a single replacement may tend to throw other worn parts to a new position, perhaps producing noise or wear at new points. A complete repair job is the only type of repair job that gives satisfaction in the long run. A single defective or worn part left in a pump by a repairman can cause disaster to some vital part, or maybe the whole mechanism, as well as a dissatisfied customer.

I have known well owners to have costly trouble simply because the driller did not install a strainer to keep out sand. Perhaps such wells can be depended upon to furnish all the water required as long as the pumps are working, but when the valve leathers (or even the valves themselves) have been cut out by constant exposure to sand in the water, there may be a costly shutdown for repairs, with delayed production, and consequent loss of profit. In such cases, the loss incurred may exceed the price of a suitable strainer by a dozen or more times.

All types of pumps have their advantages and disadvantages; and when the driller is allowed his preference in the selection of a pump, it may be wise to consider the type of water (freedom from, or presence of, minerals, sand, etc.) the type of service desired, particularly the amount of water required, the speed with which it must be delivered, as well as the general conditions prevailing at a certain well. For instance, I know of a well with water highly saturated with iron and other minerals which cause an excessive accumulation of rust, slime, or other adhering matter in and on the valves of a well known jet pump, causing constant trouble with unpriming which occurred during idle periods between irregular periods of use. The trouble persisted until the owner installed a piston-and-cylinder type of pump to eliminate the unpriming. I am not condemning any type of pump, but do believe ALL conditions should be considered in choosing one.

WE MEASURE PUMP FLOW WITH $15 WORTH OF EQUIPMENT

By HENRY E. ZEFFREN

IN POWER PLANT and industrial work, it is often desirable to get a fairly accurate figure on the total quantity of water or other liquid pumped by various pumps. For economic reasons, it may not be possible to put a flow meter on the line or pump in question. The writer hit upon a method whereby a pretty accurate figure of gallons pumped is obtained with a total expenditure of $15 for equipment.

The motor on the pump in question operates at 440 v., 3 phase, and the pump supplies a water-treating tank. It starts and stops at the dictate of a float switch on the tank, and pumps at a constant rate while running. By setting the discharge valve on the pump so that the discharge pressure is at 7¾ psi., the pump delivers 48 gpm, which is determined by measuring the rise of the tank level when the pump is on, using a stopwatch to measure time

"I have other things to do, Frumph, besides look for your oil can."

ARE

Hidden Costs...

Keeping Your Plant Efficiency Out of Balance?

Today, as always, costs (hidden or otherwise) are a prime factor in shaping plant operating efficiency. And it's obvious that when efficiency sags, plant operating costs go out of balance. How, then, can *you* best control this "economic see-saw"?

Since water conditioning is a necessary part of efficient plant operation, why not seek ways to make every dollar work harder—with the use of a *correct* water conditioning service designed to help you keep your plant functioning on the profit side year in and year out.

If the results you are presently obtaining are not entirely satisfactory, let us explain how the BETZ specialized water conditioning service can benefit you. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: BETZ Laboratories Limited, Montreal 1.

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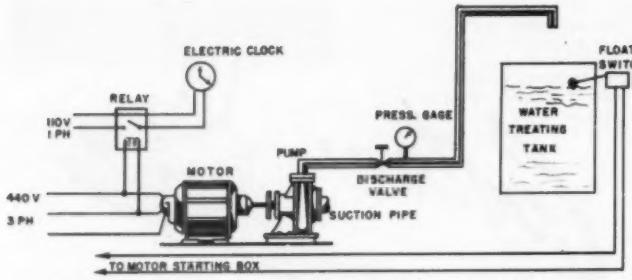


Diagram of Zoffren's $15 control system for motor-driven centrifugal pump

to deliver the water. An accurate 0-15-lb pressure gage is used.

To measure time the pump runs during a given period, a single-phase relay, with 440-v closing coil, and 110-v contacts, is placed across two terminals of the pump driving motor, and the 110-volt output is connected to a standard Telechron wall clock, which will then start whenever the pump starts, and stop whenever the pump stops.

At the end of each day, a reading is taken from the Telechron clock, and the gallons pumped for the period are calculated. The results may be used to calculate chemical dosage, plant water consumption, and savings realized by use of the water treatment system.

Total equipment purchased for the flow meter consisted of the electric clock (self-starting type of course), pressure gage, and 440v-110v relay, at a total cost of $15. Incidentally, a small 440-110v transformer may be substituted for the relay if desired.

PORTABLE ION-EXCHANGE UNIT YIELDS 10-MILLION-OHM WATER

Low-cost apparatus uses Amberlites in mixed bed. Meter shows output quality

WATER WHICH is virtually free from ionized impurities can now be produced quickly and at low cost by the new mixed-bed technique of ion exchange operated in a miniature exchange unit which weighs but 5½ pounds and requires only one-third of a square foot of bench space. To the worker in operating, research or school and university laboratories, the new apparatus appears to offer a ready supply of high-quality water for preparing stock solutions and for the scores of laboratory operations normally dependent on distilled water.

The new apparatus, called the Deeminizer by its manufacturer, the Crystal Research Laboratories Inc. of Hartford, Conn., yields up to five gallons per hour of water equal in chemical quality to triple-distilled. Fed with ordinary tap water, it can deliver a product with an electrical resistance of 10 million ohms—containing, in other words, only one part of ionic solids per 100 million parts of water.

It represents the first commercial application of the mixed-bed ion exchange technique, an important discovery made by researchers at the Resinous Products Division of Rohm & Haas Co., Philadelphia chemical manufacturer. The instrument itself consists of a rigid polystyrene tube which accommodates a replaceable container filled with Deeminite—a mixed bed of specially converted Amberlite exchangers. The tube is mounted on a gray metal base, measuring 6 x 8 in., which houses the meter.

In operation, a jar of water is upended in the top of the tube; the water passes through glass-fiber filters which remove physical impurities, then through the bed of resins which adsorb, or pick off and retain, the ionized impurities. Thus the single passage through the bed of resins produces a water free of sodium and silica, the sulfates and chlorides of calcium and magnesium, and other unwanted ions. Such a water contains no dissolved salts that interfere with the stability or accuracy of stock solutions, produce scale in steam sterilizers, or hamper the mixing and impede the working of photographic developers. The output is drawn off through a polyvinyl hose in the base.

A built-in electrical conductivity meter shows the purity of the effluent at any time, and indicates accurately when to replace the cartridge. In soft-water cities like Hartford, the manufacturer estimates that one-million-ohm water may be produced for approximately five cents per gallon; in less fortunate areas like Chicago, for example, the estimated cost would be 25 cents.

See article Monobed—Something New in Ion Exchange for Water Treatment, *Power Engineering*, October, 1950, page 94.

The new mixed-bed technique of ion exchange, applied in this portable unit, delivers water equal in chemical quality to triple distilled for the industrial or other laboratory

BEARING MAINTENANCE PAMPHLET

A CONTINUING study of bearing maintenance techniques and successful maintenance, installation, and removal procedures is being published, within a few weeks, in pamphlet form by The Anti-Friction Bearing Distributors Association of 1900 Euclid Avenue, Cleveland 15, Ohio.

This is the first attempt, as far as the Association knows, to publish in permanent form all available maintenance information on every type of bearing.

A file folder type of binder is being sent to each bearing user who requests it, on company letterhead, in which succeeding issues can be compiled.

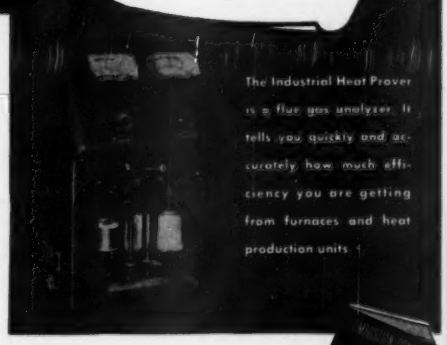
The Association is anxious to make this information available to industry at this time when such a strain is being placed on existing equipment and replacements tend to become more difficult.

At the present time too many bearings are being replaced for reasons other than normal fatigue which in most cases is due to faulty maintenance practice. Proper distribution and use of the material to be published should reduce this loss to a reasonable minimum.

TO CORRECT
Combustion Losses...
Know the cause!
A TYPICAL EXPERIENCE
"We were baffled... until this amazing mechanical detective showed us how to step up power output!"
Midwest Plant Supt.

Rule-of-thumb methods in tracing causes of fuel waste and power loss have been made obsolete by the Cities Service Industrial Heat Prover. A recent case is typical: Heat was plainly being wasted; production was suffering, and routine "corrections" had failed. Then a Cities Service engineer was called in. As always, a Heat Prover test quickly supplied data on major combustion factors. The evidence pointed to outright heat leakage – confirmed by discovery of cracked brickwork. After repairs the average power output jumped 22%!

Similar contributions to production efficiency are reported often—because the reliability of Heat Prover combustion analysis makes it simpler to determine effective corrections. Ask about this service for your plant.


The Industrial Heat Prover is a flue gas analyzer. It tells you quickly and accurately how much efficiency you are getting from furnaces and heat production units.

FREE – Booklet completely describes the Cities Service Heat Prover. Mail coupon for your copy.

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Questions and Answers

Question No. 480

HE WANTS TO KNOW ABOUT BEARINGS

1. WHAT IS the proper way to take lead readings on sleeve bearings on pumps or blowers?

Is it proper to take a reading on a sleeve bearing by using a 5-amp wire on both sides of the bearing and one over the journal, then compress your lead, take both side readings and subtract from your journal reading?

2. Are the lead-base and tin-base babbitt metals the best to use for bearings—assuming you are still able to get them under present restrictions? If not, what materials could be used for rebabbitting bearings? How many different kinds of babbitt metal are there and what are they for?

3. Is it customary to pour babbitted bearings around a mandrel smaller than the shaft, then bore out to nearly shaft diameter before "scraping in" the bearings?

4. How should babbitted bearings be grooved? And why do they need grooves?

Philadelphia, Pa. A. C.

Answer No. 476

WHY DID HIS POWER FACTOR CHANGE?

THEY USE about 650,000 kwhr of electricity a month for mill processes, said J. B. in the January issue. They have just enough capacitors on the mill side to give them an operating power factor of 80.5 to 82 per cent. In April 1950 they installed a compressor driven by a 75-hp induction motor, which does not require more than 60 per cent of its capacity to drive the compressor at full load.

Now in May 1950 they operated with 81.5 per cent power factor but in July the power factor dropped to 79.5 and in the following months dropped below 79.

All other factors were the same. If the decrease was caused by the new motor, why didn't it show up in May, instead of later? What factors are they overlooking in trying to account for this?

Barabas Calculates Power Factor

The writer is not familiar with utility company's billing methods or plant operations as to type of major equipment, and so on, within the confines of the plant. But, assuming plant operations on a 21-day month, 24-hr-day, utilizing 650,000 kwhr per month, with a power factor of 80.5 per cent to 82 per cent it would indicate approximately 530 kw are demanded on a 15-min basis, with 650 kva taxed on power transformation apparatus before the installation of the 75-hp squirrel cage motor.

It will also be well to point out that the utilization factor of a 75-hp motor placed on the system 60 per cent loaded, develops 45 hp (440 v, 3 phase 60 cycle) with a power factor of approximately 58-60 per cent under present conditions, with the remaining copper and iron within the 75-hp frame doing no useful work but aggravating the previous power factor of the system with circulating current and increasing the kva of the system.

In summation, when the motor was added to the system the present 650 kva was increased by 70 kva, making a total of 720 kva demanded, with 530 kw plus 34 kw required by the air compressor, making a total of 564 kw required for work, resulting in a power factor of 564÷720 or 78 per cent.

The above is true only if all loads within the plant are fairly consistent; if changes here should occur, like loads falling off, this may decrease the power factor still further, resulting in still a lower power factor condition, for which penalties may be imposed.

In closing, if J. B. would care to add a capacitor across his present 75-hp frame, suitable to bring the kilovars up on the motor, say around 17.5 kva—if the motor is 1200 rpm or 20 kva if 900 rpm—he could possibly reduce his circulating current by 8 per cent to 11 per cent, which would, no doubt, aid in his present setup.

Trenton, N. J. JOHN J. BARABAS

Comments by von Dannenberg

DETAILS given are too limited to enable more than some general comments to be made. Actually the whole over-all range of power factor, 82.0 to less than 79, is not great. In the writer's experience, contracts have usually included blocks of 5 per cent for any criterion as a basis for charge. In fact, depending upon how the value of power factor was obtained, whether by actual test, curve-drawing (graphic) chart, or ratio of total kilovar hours to kilowatt hours, this range of power factor would not be at all out of line. Possibly the comparison of the last named—the ratio of kilovar hours to kilowatt hours—would give as close a value to an average as any commercial method available and the result would be sufficiently accurate.

It is not stated whether there is any local generation. If so, the variation in the field currents would have an influence on the total load power.

Since no diagram of connections is given, showing the location of the points of measurement, one cannot be certain how the values of power factor given were arrived at for the whole system.

The existence of capacitors suggests the possibility that some of the units may be faulted or out of service. Tests will readily indicate such a condition, which should be remedied at once.

There is no statement about the balance of the line currents, which has a decided influence upon the value of power factor indicated. The conventional type of meter used invariably depends upon or assumes a balanced condition. Actually the most accurate measurement of power factor would be to take three readings of current, with three readings of watts and three readings of voltage to neutral. When summed up, these would give an accurate indication of the result desired. There is no generally available meter of this type in use in the U.S.A. However, as stated before, the comparison of kilovar hours to kilowatt hours with meters correctly located will give accurate comparative results.

Brooklyn, N. Y. C. O. VON DANNENBERG

Should Have Been a Synchronous Motor, Says Evans

THE INFORMATION given is too vague for a definite answer. However, here are a few generalities.

The induction motor, even though it constitutes a small percentage of the total load, should have been a synchronous motor. The pf may be as low as 60 per cent at full load on the compressor, because of the oversizing of the motor. Wherever possible, size induction motors for the load imposed, for the pf drops off rapidly with load. If a synchronous motor had been used, it would actually have improved pf by proper excitation of the field, especially at part load, at which time it would have acted as a synchronous condenser. Placing a proper-sized capacitor at the induction motor would help.

If the pf given is at time of maximum demand, the pf should be at a high value. However, if the maximum demand happened to be a lot of small induction motors (even at full load), the pf would be low.

Your plant load may have decreased with the same number of motors on. It is possible that your condenser, in one of the feeders, has become inoperative and that it is not neutralizing the lagging current.

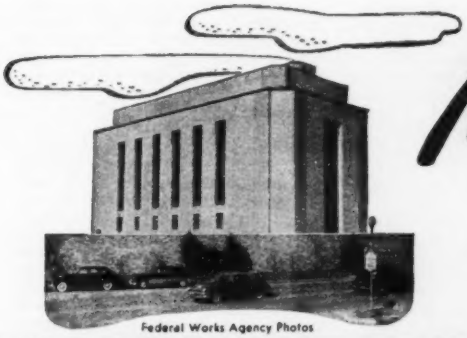
Chicago, Ill. MELVIN EVANS

Answer No. 477

WHAT IS BEST HEATING SYSTEM FOR A CHURCH?

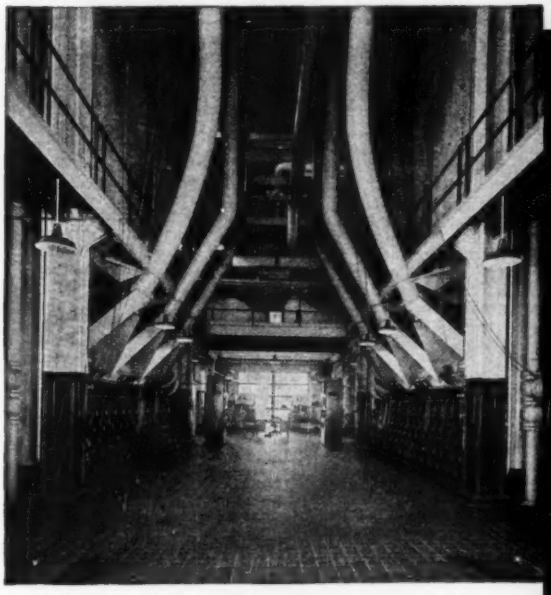
Forced-hot-air System Best, says Wright

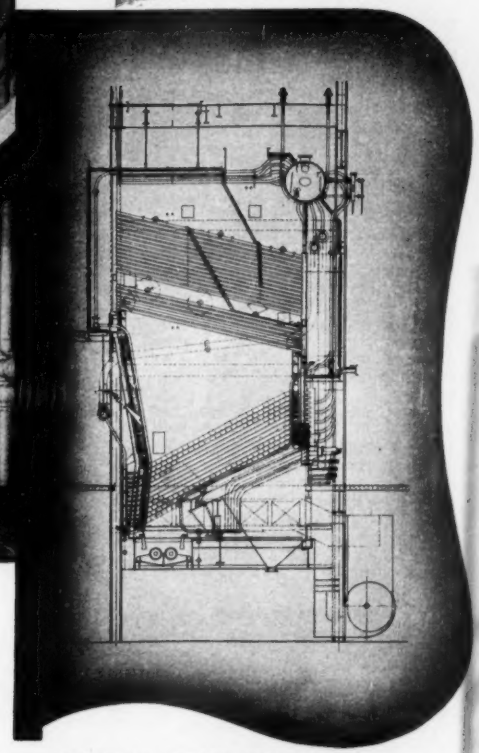
IN THIS AREA, and the same is true in most places outside of the large cities, churches are used only a few times a week; perhaps not more



Federal Works Agency Photos

More Heat for the NATION'S CAPITAL





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Principal Data, Each Unit

220,000 pounds steam per hour capacity Steam and water drum is fusion welded and designed for 400 pounds S.W.P. Sinuous forged steel tube headers. Water cooled furnace walls.

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than two or three days and these scattered. It is the custom to heat the building up for the services and have no heat or, at most, just enough to prevent freezing the rest of the time.

No matter what type of plant is installed, first cost is very important, as well as the cost of operation and upkeep. If we are to heat the building only during services, we want a system that will heat up quickly and, when shut down, have nothing to freeze if the temperature drops too far between times.

Steam and water lines are always apt to develop leaks and damage the walls and floors, especially in a building not in constant use, before they are discovered.

The Custodian of most churches is far from an experienced engineer, in most cases. The plant that is the most simple, has little to require attention or develop trouble is the best one for him.

The forced-hot-air system meets all these requirements in fine shape.

In the last five or six years, several churches in this area have installed new heating plants and, in all cases but one, they have been forced-hot-air jobs. Two were rather large buildings with attached chapels and Sunday School rooms. We installed a zoned system so that any part could be heated without having to heat all.

Every one of these plants has worked out well and the owners are well satisfied. If desired, system could be worked out to introduce fresh air as well as to recirculate it in the building. This would remove odors, decrease disease germs, etc. In fact, the hot-air system can be designed to meet any conditions.

Woodbourne, N. Y. DEAN E. WRIGHT

Comparisons by Eckert

I DO NOT think that any one of the three systems—steam, hot water or forced air—could be called the best system. Each has a very definite advantage at proper applications. Any heating system must be selected to fulfill certain requirements which may vary considerably even in similar types of buildings.

My personal opinion would tend toward the forced-air system if the church is rather small and does not have daily attention by a custodian. Reasons are that a church is usually not used except for a short time each day and sometimes it is used only 3 or 4 times a week. In such a case, the forced-air system can be shut down during periods of non-use, with some fuel savings. Since there is no water in such a system, there is no danger of freeze-up. Make the system oversize enough to be able to warm up building with reasonable speed without danger of overheating. Chances are that the forced-air system would be the cheapest.

If, however, the church is good size and has considerable activity and too has the daily service of a custodian, I would prefer a forced hot water system with latest type control devices. In this type system, the church building temperature can be controlled with great accuracy. Of course, heat must be maintained at all times to a point above freezing during winter seasons, thus consuming fuel. With careful handling, this type system does not have to be too much oversized due to the constant nature of firing under load continuously.

Steam is a great deal the same as the hot water system, although not as accurate in control. However, in the hands of a good man, I doubt much difference can be noted in room temperature. Here again heat would have to be maintained during freezing weather.

Steam and hot water systems would very likely be more expensive in first cost.

Mt. Vernon, Ill. ALBERT R. ECKERT

Comparisons by von Dannenberg

AS A GENERAL STATEMENT, in the average community the matter of cost, in actual cash, for the installation tends to be a major consideration, so economic rather than hygienic features usually decide the issue.

Since the size of the church, the area and cubic space, as well as architectural features, are definite governing elements, the scope of the question can be realized.

From actual experience the writer would place the three systems, in order of desirability, as follows:

1. Forced hot-air heating
2. Hot water heating
3. Steam heating

Let's consider each of them in detail.

1. Forced hot air heating.

This system, known to most of us as furnace direct-air heating, lends itself to results which, through the use of a water pan or box, enable the air to be humidified automatically. As a result, the maximum dry bulb thermometer temperature need rarely exceed 65 F. This is a most valuable property not common to either of the other two systems. Besides having a fan in the air intake, other fans can be inserted in the branch risers, if desired, to increase effective heat transmission.

For a church where most of the space to be heated is at the same level, it may even be desirable to have several heaters in larger areas, with single outlets arranged on the one-pipe heater principle. The fact that there is practically nothing to freeze and the ease of providing heat on short notice perhaps only one or two times per week, make such a system worthy of consideration unless the area is quite large. In addition (and this applies to all three systems where the ceiling is high or of the vaulted type) fans to direct the high warm air to lower levels can be arranged as an added advantage.

2. Hot Water Heating.

This has the advantage of having the temperature of the radiators definitely under control. It is surprising how quickly the system responds through the immediate circulation of the water when the heat is applied at the furnace. For a church where most of the radiators are at one level, use of one or more pumps is indicated, to force the circulation necessary even with a higher level accumulator. The pumps are comparatively small and can be electrically operated. There is no control of relative humidity except by some external means.

This system requires attention in the winter time to prevent freezing, although very little fuel is required to keep enough circulation for the purpose of protection.

3. Steam Heating.

This requires raising the temperature of the water to slightly above 212 F or very close to it, if a return system is used. There is no control of the temperature and it is not uncommon to have values as high as 80 F where only the dryness of one's throat indicates the extreme temperature existing. Effect of the high temperature is noticeable when leaving the building.

For an extended system a return pump may keep the pressure to a minimum; some of the so-called vapor systems, where the pressure is barely higher than the atmosphere, use this feature but the control of the temperature is still the poorest of the three systems.

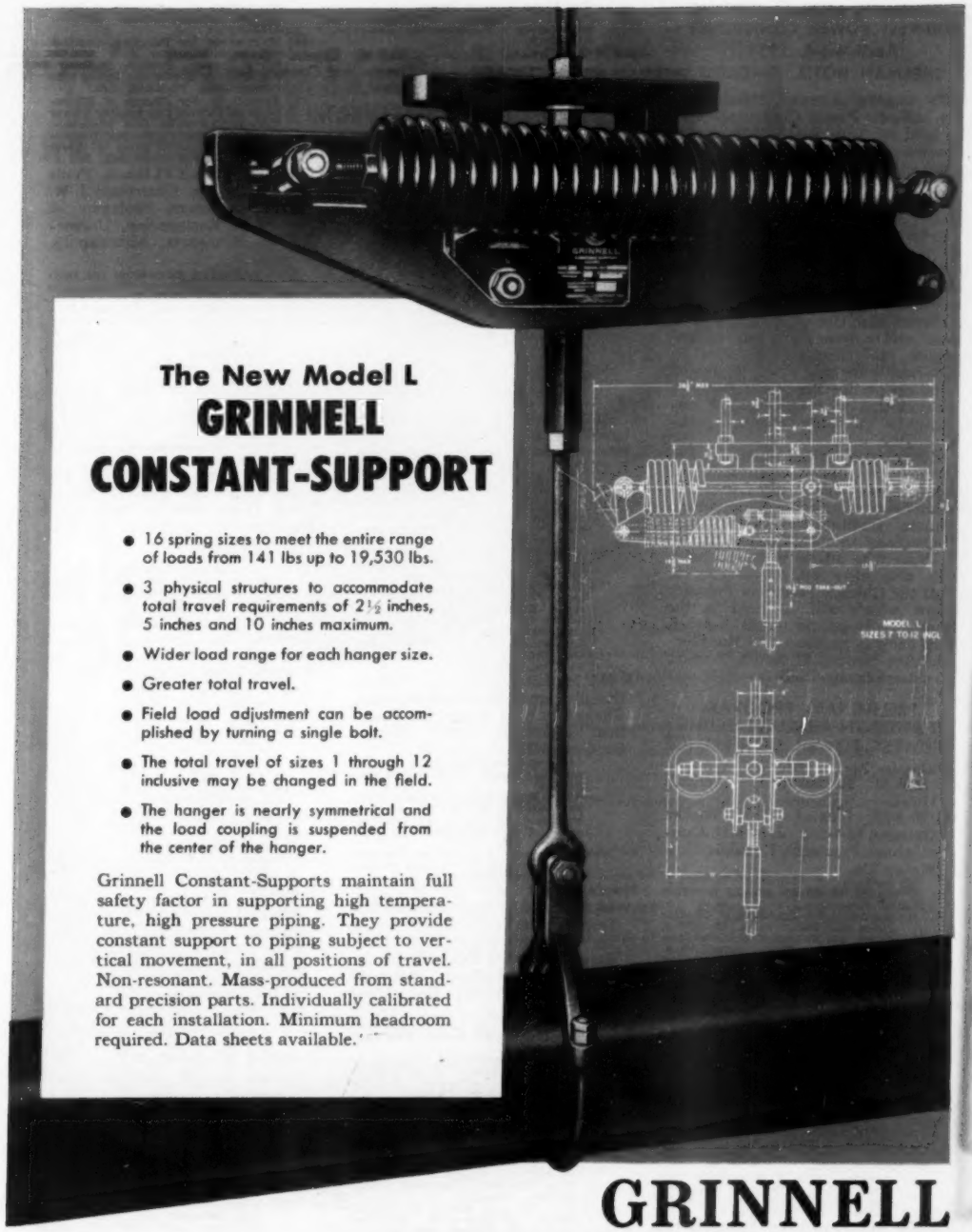
Size of piping and radiators together with the heating plant may be less than for No. 2, with possibly lower total cost, but for any installation it indicates how a comparatively simple problem can have so many pertinent angles. As in No. 2, provision must be made to prevent freezing during the weekly idle periods.

The foregoing are merely a few of the elements concerned in choosing a system and any decision ought to at least discuss the features from their relation to the final result desired.

The writer has even found, in an area where hydroelectric-generated electricity is available, church pews equipped with individual heaters under the seats, controlled at will by the occupant. This, in a way, is comparable to the system now in use on sleeping cars where each section has control of its own air-conditioning unit independendent of the others in the car. At least if it is easy to apply local electric heating, such a system merits consideration.

Brooklyn, N. Y.

C. O. VON DANNENBERG



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THIRTEENTH ANNUAL MEETING MIDWEST POWER CONFERENCE

April 4-5-6, 1951

SHERMAN HOTEL, CHICAGO

THIRTEENTH ANNUAL Meeting of the Midwest Power Conference will be held on April 4-5-6, 1951, at the Sherman Hotel in Chicago. The program will consist of twenty-six technical and general interest sessions, three luncheons and the All Engineers' Dinner. The technical sessions will be devoted to subjects covering all phases of the power industry.

The Conference is sponsored by the Illinois Institute of Technology in cooperation with nine Midwestern Colleges and Universities and nine local and national engineering societies. Its purpose is to offer an opportunity for all persons interested in power production, transmission or consumption to meet together annually for the study of mutual problems.

Everyone is invited to attend. For further information concerning the Conference, write to Edwin R. Whitehead, Conference Secretary, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Those who attend the Conference will also have an opportunity to visit the Chicago Electrical Industry Show which will be held in the Sherman Hotel on April 3-4-5-6. This show is sponsored by the Electric Association, 37 South Wabash Avenue, Chicago 3, Ill.

PRELIMINARY PROGRAM THIRTEENTH ANNUAL MEETING MIDWEST POWER CONFERENCE

Wednesday, April 4, 1951

8:30 A.M. Registration, Sherman Hotel.

10:30 A.M. Grand Ball Room. Opening Meeting. James D. Cunningham, President, Republic Flow Meters Co.

(a) Address of Welcome. Henry T. Heald, President, Illinois Institute of Technology.

(b) Response for Cooperating Universities and Societies. L. G. Miller, Dean of Engineering, Michigan State College, East Lansing, Mich.

(c) The Engineer's Responsibility in the Fight Against the Disintegration of the Foundations of Freedom. W. C. Mullendore, President, Southern California Edison Co., Los Angeles, Calif.

(d) Walker L. Cisler, Executive Vice President, The Detroit Edison Co., Detroit, Mich. Subject to be announced.

12:15 P.M. College Inn. Midwest Power Conference Luncheon—Program sponsored by Chicago Section ASME. Chairman: R. S. Hartenberg, Chairman, Chicago Section, ASME.

Speaker: John T. Rettaliata, Vice President and Dean of Engineering, Illinois Institute of Technology. "Jet Propulsion."

2:00 P.M. Grand Ball Room. Large Steam Generators. Chairman: F. D. Carvin, Chairman, Department of Mechanical Engineering, Illinois Institute of Technology.

(a) Spreader Stokers for Large Boilers. J. S. Bennett, Vice President, American Engineering Co., Philadelphia, Pa.

(b) The Trend Toward Reheat. H. G. Ebdon, Vice President, Combustion Engineering - Superheater, Inc., New York.

2:00 P.M. Crystal Room. Water Supply and Conservation. Chairman: John H. Herzog, President, National Association of Power Engineers.

(Sponsored and arranged by the National Association of Power Engineers.)

(a) The Ground-Water Resources of the Midwest. Frank C. Foley, District Geologist, U. S. Department of the Interior, Madison, Wis.

(b) To be announced.

2:00 P.M. Louis XVI Room. Power Transmission at High Voltage. Chairman: W. A. Lewis, Dean of the Graduate School, Illinois Institute of Technology.

(a) High Voltage Transmission. S. B. Crary, Analytical Division, Application and Service Engineering Divisions, General Electric Co., Schenectady, N. Y.

(b) Extra High Voltage Transmission. H. P. St. Clair, System Planning Engineer, American Gas & Electric Service Corp., New York.

3:30 P.M. Grand Ball Room. Ridgeland Station—A Step Forward in Power Generation. Chairman: E. C. Bailey, Chairman, Power and Fuels Division, Chicago Section, ASME.

(Sponsored and arranged by Power and Fuels Division, Chicago Section, ASME.)

(a) Mechanical Design and Construction. H. C. Schroeder, Partner, Sargent & Lundy, Chicago.

(b) Electrical Design and Construction. John C. Woods, Station Design Engineer, Commonwealth Edison Co., Chicago.

(c) Operating Experiences. Ralph B. Gutekunst, Chief Engineer, Ridgeland Station, Commonwealth Edison Co., Chicago.

3:30 P.M. Louis XVI Room. Industrial Systems (Electrical Session). Chairman: R. D. Borgstadt, Chairman, Industrial Group, Chicago Section, AIEE.

(Arranged and sponsored by Industrial Group, Chicago Section, AIEE.)

(a) Motor Speed Control on A-C Power Systems. E. W. Seeger, Vice President in charge of Development, Cutler-Hammer, Inc., Milwaukee, Wis.

(b) Grounding of Industrial Systems. W. C. Bloomquist, General Electric Co., Schenectady, N. Y.

Thursday, April 5, 1951

9:00 A.M.—12:00 Noon. Grand Ball Room. Water Technology Session No. 1. Symposium on Organic Water Treatment Materials. Chairman: Glen Andrews, Manager Utilities, Shell Oil Co., Wood River, Ill.

(Sponsored by Joint Research Committee on Boiler Feedwater Studies.)

(a) The Development of Organics for Water Treatment. J. A. Holmes, Assistant Vice President, National Aluminate Corp., Chicago.

(b) Organic Agents in Boiler Scale and Sludge Control. John J. Maguire, Director, Technical Division, W. H. and L. D. Betz, Philadelphia, Pa.

(c) Organic Synergists in Foam Control. C. M. Bodach, Chief Chemist, and L. O. Gunderson, Assistant Vice President, Dearborn Chemical Co., Chicago.

(d) The Use and Misuse of Organic Water Conditioning Materials. Robert W. Liddell and Louis C. Bishop, Hall Laboratories, Inc., Pittsburgh, Pa.

9:00 A.M. Crystal Room. Electronics in Power Systems. Chairman: R. E. Beam, Chairman, Electronics Group, Chicago Section AIEE.

(Sponsored and arranged by Electronics Group, Chicago Section, AIEE.)

(a) Microwaves for Relaying, Control and Communication. A. W. Adams, Relay Section, System Engineering Branch, Bonneville Power Administration, Portland, Ore.

(b) Factors in the Choice of Microwave or Carrier Current for Power System Operation and Dispatching. F. C. Krings, Central Station Engineering Division, General Electric Co., Schenectady, N. Y.

9:00 A.M. Louis XVI Room. Fuels and Combustion. Chairman: J. W. Andeen, Assistant Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn.

(a) A Method of Estimating the Ultimate Analysis of Bituminous Coals from the Proximate Analysis. Edward W. Jerger, Assistant Professor of Mechanical Engineering, and John R. May, Instructor of Chemical Engineering, Iowa State College, Ames, Ia.

(b) Operating Experiences with Combination Blast Furnace Gas, Coke Braize, and Oil Fired Boiler at Wisconsin Steel. C. D. Northam, Superintendent, and John T. Harvey, Assistant Superintendent of Steam Power, Wisconsin Steel Works, International Harvester Co., Chicago.

10:30 A.M. Louis XVI Room. Fly Ash. Chairman: Ben. G. Elliott, Head, Department of Mechanical Engineering, University of Wisconsin, Madison, Wis.

(a) To be announced.

(b) Practical and Workable Air Pollution Control Ordinances. Joseph C. McCabe, Associate Editor, Power, New York.

10:30 A.M. Crystal Room. System Control and Operation. Chairman: D. L. Levine, Chairman, Power Group, Chicago Section, AIEE.

(Sponsored and arranged by Power Group, Chicago Section, AIEE.)

(a) A High - Speed Load - Frequency Control System. T. L. Mell, Brown Instrument Division, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

(b) Excitation Control. M. Temoshok, Power Generation Division, Central Station Engineering Divisions, General Electric Co., Schenectady, N. Y.

(c) Electronic Excitation. J. E. Barkle and D. F. Schankle, Central Station Engineers, Westinghouse Electric Corp., East Pittsburgh, Pa.

12:15 P.M. College Inn. Midwest Power Conference Luncheon—Program sponsored by Chicago Section AIEE. Chairman: E. L. Michelson, Chairman, Chicago Section, AIEE.

Speaker: Jack T. Wilson, Chief Physicist, Allis-Chalmers Manufacturing Co., Milwaukee, Wis. "What Can the Engineer Contribute to Better Living."

2:00 P.M. Grand Ball Room. Soot Removal and Minimizing Fireside Deposits.

(a) Retractable Soot Blowers in Central Station Boilers—Comparison of Air and Steam Blowing. D. E. Hibbner, Vice President, Vulcan Soot Blower Division, Continental Foundry and Machine Co., Dubois, Pa.

(b) Minimizing Fireside Deposits by Humidification of Combustion Air. Paul Murphy, Jr., Boiler Room Engineer, and John D. Piper, Chemical Supervisor, Research Laboratory, The Detroit Edison Co., Detroit, Mich.

2:00 P.M. Louis XVI Room. Hydro Power. Chairman: E. B. Kurtz, Professor of Electrical Engineer-

(Continued on page 98)

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MIDWEST POWER CONFERENCE

(Continued from page 96)

ing, State University of Iowa, Iowa City, Iowa.

(a) The Tennessee Valley Authority Hydroelectric Program. Harry Wiersema, Assistant to the Chief Engineer, Tennessee Valley Authority, Knoxville, Tenn.

(b) Problems in Power Plant Design for Reclamation Multiple Purpose Projects. Ireal A. Winter, Head, Hydraulic Machinery Division, Bureau of Reclamation, Denver, Colo.

2:00 P.M. Crystal Room. The Heat Pump.

(a) Influence of Freezing on Heat Pump Ground Coil Capacity. A. D. Kafadar and I. B. Fieldhouse, Research Engineers, Armour Research Foundation, and R. A. Budenholzer, Professor of Mechanical Engineering, Illinois Institute of Technology.

(b) To be announced.

3:30 P.M. Louis XVI Room. Power Generation Equipment. A. H. Lovell, Head, Dept. of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

(a) Balancing Large Turbo-Generator Rotors. P. R. Heller and C. H. Janthey, Design Engineers, A.C. Generator Section, Westinghouse Electric Corp., East Pittsburgh, Pa.

(b) Pumped Storage Hydro-Electric Power. William J. Rheingans, Assistant Manager, Hydraulic Department, Frank Jaski, Assistant Chief Engineer, Hydraulic Dept., and H. H. Roth, Application Engineer, Motor and Generator Section, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

3:30 P.M. Grand Ball Room. Small Power Plants. Chairman: A. J. Snider, Combustion Engineering-Superheater, Inc., Chicago.

(a) New Materials and Construction Methods for Small Power Plants. C. Maxwell Stanley, Partner, Stanley Engineering Corp., Muscatine, Ia.

(b) To be announced.

3:30 P.M. Crystal Room. Residential Applications of Electric Power Heating and Hot-Water Supply. Chairman: M. A. Faucett, Professor of Electrical Engineering, University of Illinois, Urbana, Ill.

(a) Load characteristics and Economics of Electric House Heating. W. F. Friend, Ebasco Services, Inc., N. Y.

(b) To be announced.

6:30 P.M. Grand Ball Room. All Engineers Dinner. Informal. (Ladies Invited.)

Friday, April 6, 1951

9:00 A.M. Crystal Room. Power System Grounding. Chairman: D. D. Ewing, Head, School of Electrical Engineering, Purdue University, Lafayette, Ind.

(a) Trends in Power System Grounding. E. T. B. Gross, Professor of Electrical Engineering, Illinois Institute of Technology, Chicago.

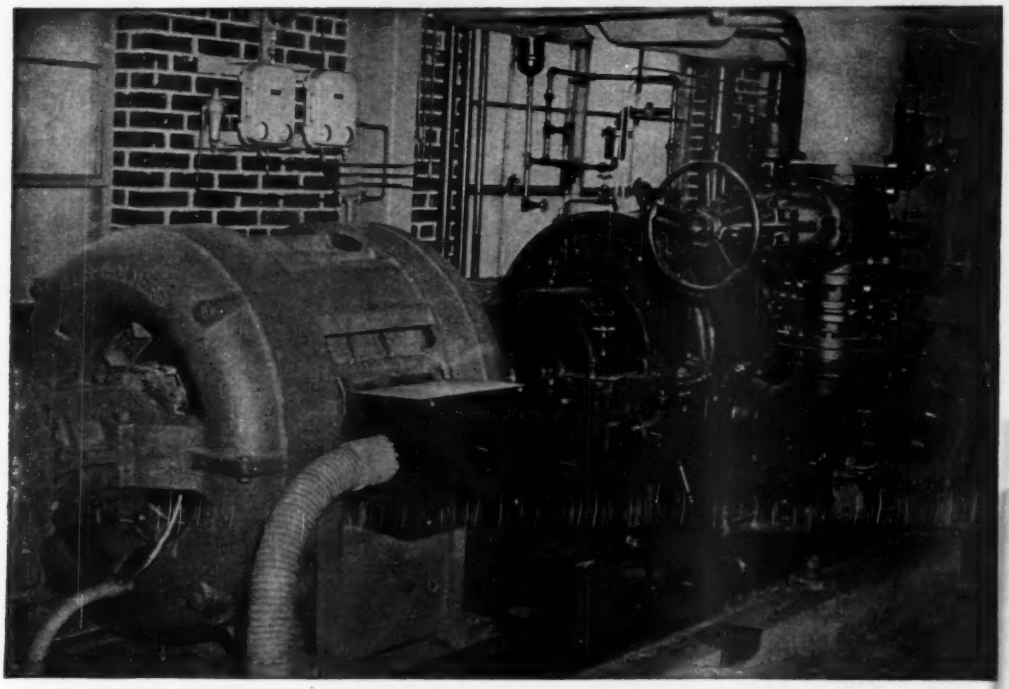
(b) The Delta-Grounded Transformer Development and Application. H. L. Hoeppner, Pioneer Service and Engineering Co., Chicago.

9:00 A.M. Grand Ball Room. Water Technology Session No. 2. Ion Exchange. Chairman: R. T. Hanlon, Chairman, Water Technology Division, Chicago Section, ASME.

(Sponsored and arranged by Water Technology Division, Chicago Section, ASME.)

(a) Experience with Silica Removal Demineralizer Plants. S. B. Applebaum, Manager, Cold Process Division, Cochrane Corp., Philadelphia, Pa.

The TERRY TURBINE



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(b) Boiler Feedwater Treatment for a High Pressure, High Makeup Power and Steam Producing Plant. V. J. Calise, Technical Director, Graver Water Conditioning Co., New York; J. Harlow, Chief Mechanical Engineer, and H. Farmer, Chief Chemist, Philadelphia Electric Co., Philadelphia, Pa.; and H. Lane, Chief Chemist, Graver Water Conditioning Co., New York

9:00 A.M. Louis XVI Room. Diesel Engines and Gas Turbines for the Production of Power. Chairman: W. P. Green, Assistant Chairman, Applied Mechanics Research, Armour Research Foundation, Chicago.

(a) Use of Diesel Generating Units on the Northern States Power Company System. E. F. Carlson, Results Engineer, and H. H. Rhoades, General Superintendent of Electrical Plant Section, Northern States Power Co., Minneapolis, Minn.

(b) Power Generation by Gas Turbines. A. G. Mellor, Power Generation Division, General Electric Co., Schenectady, N. Y.

10:30 A.M. Grand Ball Room. General Session on Atomic Energy for Power Generation. Chairman: G. Ross Henninger, Professor of Mechanical Engineering, Iowa State College, Ames, Iowa.

(a) Atomic Energy—A Review of Fundamentals. Frank H. Spedding, Director, Institute of Atomic Research and Ames Laboratory, Iowa State College, Ames, Ia.

(b) Atomic Energy and the Power Industry. George G. Brown, Director, Engineering Division, Atomic Energy Commission, Washington, D. C.

12:15 P.M. College Inn. Midwest Power Conference Luncheon—Program sponsored by Chicago Section, WSE. Chairman: H. P. Sedwick, President, Western Society of Engineers.

Speaker: John Slezak, President, Turner Brass Co., Chicago. "The Engineering Mind in Business."

2:00 P.M.—5:00 P.M. Grand Ball Room. Progress in Gas Turbine Locomotive Development. Chairman: John T. Rettaliata, Vice President and Dean of Engineering, Illinois Institute of Technology.

(a) Progress Report on the Coal-Burning Gas Turbine. J. I. Yellott, Director, and P. R. Broadley, Assistant Director of Research, Locomotive Development Committee, Baltimore, Md., and F. D. Buckley, Manager, Research and Development Division, Locomotive Development Committee Project, American Locomotive Co., Dunkirk, N. Y.

(b) Alan Howard, General Electric Co. Schenectady, N. Y. (Subject to be announced.)

(c) T. J. Putz Westinghouse Electric Corp., Philadelphia, Pa. (Subject to be announced.)

(d) W. B. Tucker, Allis Chalmers Manufacturing Co., Milwaukee, Wis. (Subject to be announced.)

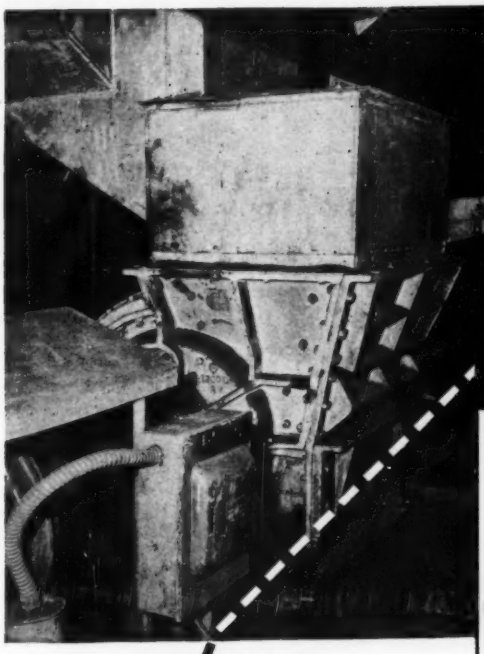
2:00 P.M. Louis XVI Room. Water Technology Session No. 3. Cooling Tower Problems. Chairman: Glenn R. Hull, General Foreman, Utilities and Conservation Division, Standard Oil Co. of Indiana, Whiting, Ind.

(a) Recent Studies in Cooling Tower Wood Deterioration. D. R. Baker, Engineering Research Division, The Marley Co., Kansas City, Kans.

(b) Equipment for Treatment of Makeup of Cooling Towers. Durando Miller, The Permutit Co., New York, N. Y.

2:00 P.M. Crystal Room. Power System Apparatus. Chairman: E. T. B. Gross, Prof. of Mechanical

These "CRUSHING" FACTS - - - - - - -



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TOTAL COST PER TON: one half of 1¢*

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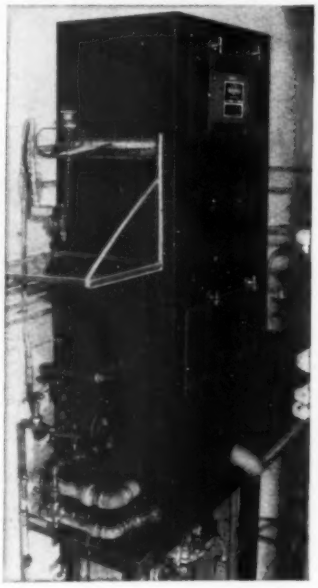

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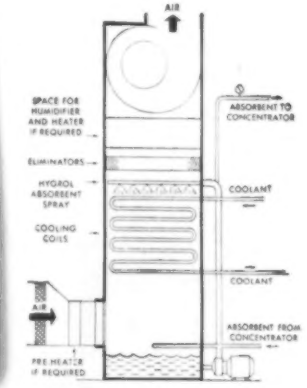

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(a) Power Transformer Acceptance Tests. Byron Evans, Assistant Head, Power System Technical Section, U. S. Bureau of Reclamation, Denver, Colo.

(b) New Developments in Lightning Arrester Design. J. H. Kalb, Ohio Brass Co., Barberton, Ohio.

3:30 P.M. Louis XVI Room. Water Technology Session No. 4. Special Problems and General. Chairman: J. D. Yoder, Vice President, Permutit Co., N. Y.

(a) Meeting the Soda Ash Shortage by Conversion of Filters to Zeolite Softeners. George H. Kraf, Power and Fuel Engineer, Carnegie Illinois Steel Corp., Pittsburgh, Pa.

(b) Feedwater Treatment in the Packing Plant. M. B. Golber, Power Plant Engineer, Armour and Co., Chicago.

3:30 P.M. Crystal Room. Power Stations. Chairman: J. A. M. Lyon, Associate Professor of Electrical Engineering, Northwestern University, Evanston, Ill.

(a) Power Plant Communication. William Jarzembski, Panellit. Inc., Chicago.

(b) Lighting for Steam Power Plants. S. L. Chapin, Electrical Engineer, Sargent & Lundy, Chicago.

New ENGINEERING BOOKS

Primary Batteries, by George Wood Vinal. Third Edition; 336 pages; illustrated; size 6 by 8½ in.; cloth; published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.; 1950; price $5.00.

Primary batteries are defined in various ways, the object usually being to distinguish them as a class from storage batteries. Both produce electrical energy as a result of electrochemical reactions. In primary cells, these reactions are utilized without regard to reversibility. Some primary cells are reversible, in part at least, but this often depends on the extent of the previous discharge. One or both of the electrodes in a primary battery are usually consumed as a result of discharge, and in their final state of exhaustion they cannot be restored to their initial condition by passing a reverse current through the individual cells. Storage batteries, on the other hand, can be restored repeatedly by charging them. Primary cells are usually discarded when they have been fully discharged, except as renewals, consisting of new electrodes and electrolyte, are available for a few types.

The present volume reflects the renewed interest in a subject that has become important with changed military and meteorological requirements. It is one of the most thorough treatments of primary batteries that has appeared for a good many years. The book describes new and unfamiliar types of primary batteries and presents the older and more familiar types in a new light.

One of the most interesting sections of the book is the first chapter, which traces briefly the historical development of primary batteries from Volta's famous pile in 1800 to the beginning of the dry-cell industry near the close of the last century. This was a period of great activity when batteries were the chief source of electricity in manageable form, before the development of electric generators.

This introductory chapter is followed by an elementary discussion of battery theory, including the relation between chemical and electrical energy. The following chapters describe dry cells of various kinds and their operation and there is considerable discussion of their behavior at low temperature (a subject important just at this time) and of the modifications that have been proposed to improve them.

Chapter 6 describes in detail various standard cells providing standards of electromotive force (that is, voltage); Chapter 7 covers air depolarized and other batter-

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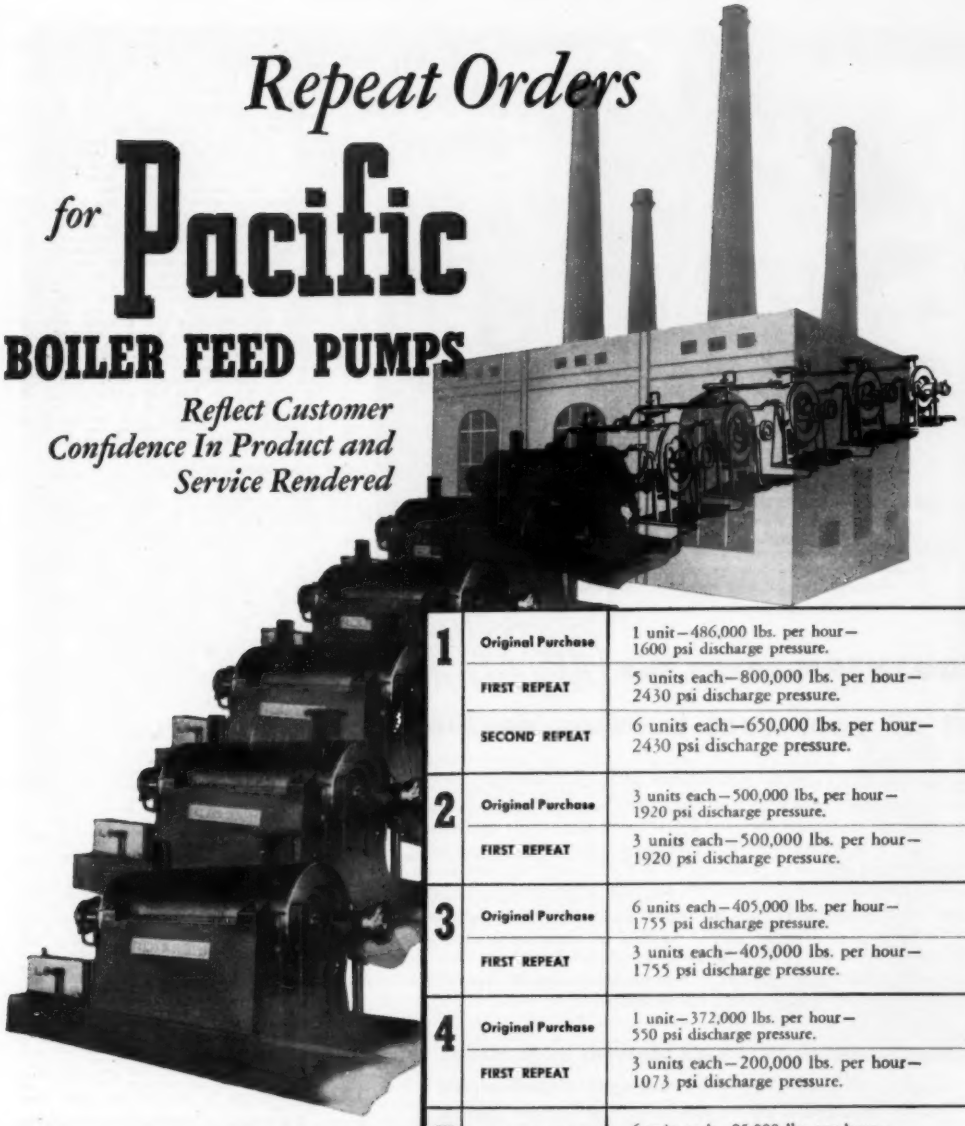

1	Original Purchase	1 unit—486,000 lbs. per hour—1600 psi discharge pressure.
	FIRST REPEAT	5 units each—800,000 lbs. per hour—2430 psi discharge pressure.
	SECOND REPEAT	6 units each—650,000 lbs. per hour—2430 psi discharge pressure.
2	Original Purchase	3 units each—500,000 lbs, per hour—1920 psi discharge pressure.
	FIRST REPEAT	3 units each—500,000 lbs. per hour—1920 psi discharge pressure.
3	Original Purchase	6 units each—405,000 lbs. per hour—1755 psi discharge pressure.
	FIRST REPEAT	3 units each—405,000 lbs. per hour—1755 psi discharge pressure.
4	Original Purchase	1 unit—372,000 lbs. per hour—550 psi discharge pressure.
	FIRST REPEAT	3 units each—200,000 lbs. per hour—1073 psi discharge pressure.
5	Original Purchase	6 units each—95,000 lbs. per hour—600 psi discharge pressure.
	FIRST REPEAT	30 units each—153,000 lbs. per hour—765 psi discharge pressure.
	SECOND REPEAT	3 units each—153,000 lbs. per hour—765 psi discharge pressure.

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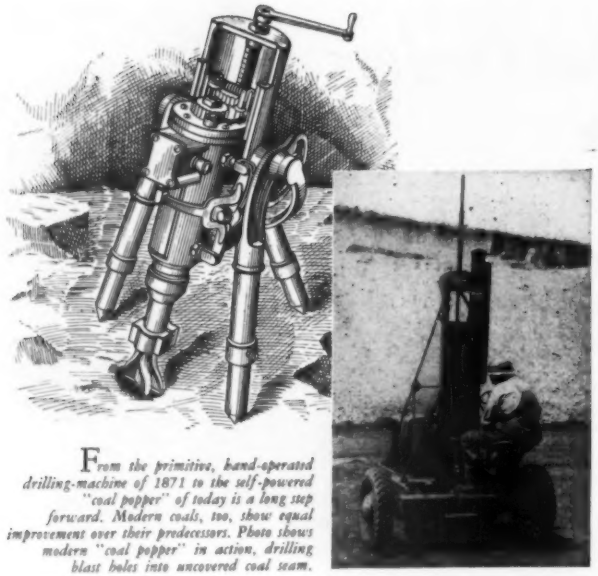

From the primitive, hand-operated drilling-machine of 1871 to the self-powered "coal popper" of today is a long step forward. Modern coals, too, show equal improvement over their predecessors. Photo shows modern "coal popper" in action, drilling blast holes into uncovered coal seam.

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MEMBER BITUMINOUS COAL RESEARCH

ies; Chapter 8, copper and copper oxide cells; Chapter 9, silver oxide and chloride batteries; Chapter 10, lead cells having soluble reaction products; Chapter 11, mercuric oxide and vanadium dry cells; and Chapter 12, fused electrolyte cells.

There is considerable discussion of the cadmium cell originally developed in 1893 by Weston as a standard cell. More recently the cadmium storage battery has been developed and is now available in this country. Some discussion of this was given in the Questions and Answers Section of this magazine last year.

There is no question that this book was needed to present all of the available information on primary batteries because of their many present day applications. It is not only a most authoritative treatment of the subject, but is also very interesting reading, for it is very well written and requires for understanding a very minimum of chemical knowledge and very little mathematics. Those who have not had occasion to investigate this subject, will be much surprised at the various types of primary batteries and the way they operate. Mr. Vinal, the author, has been Chief of the National Bureau of Standards Division of Electrochemistry since 1918 and for over 25 years has had active charge of the primary standard of the volt in the United States. In this book he has done a superlative job of writing on an important but not too familiar subject.

• • •

Steam-Plant Operation, by Everett B. Woodruff and H. B. Lammers. Revised Second Edition; 543 pages; illustrated; cloth; size 6½ by 9½ inches; published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y.; 1950; price $7.00.

This is the second edition of a book that has been widely used by power engineers since first issued in 1935. Since that time many changes and developments in the field of steam plant operation have occurred and the new edition brings both the description of equipment and the technique of operation and maintenance up to present-day accepted standards.

An example of this is the new developments in boiler construction resulting in revision of the Boiler Code, which in turn require different methods of calculating allowable working pressure and plate thickness.

Important changes in welded boiler construction have been included. Fuel oil and spreader stokers have been given more attention, as well as the latest techniques in the operation and maintenance of boilers, engines, turbines and auxiliaries. Efficient plant operation and fuel economy are becoming constantly more important and the book reflects this by increased emphasis on these subjects. Questions and problems, as well as answers to the problems, are included at the end of each chapter.

One of the reasons for this book's popularity is that the authors have been conscious at all times of the fact that by far the majority of steam plants in the country are the relatively small plants employed by most industries, as contrasted with the very large plants employed by the power utilities. Accordingly, while discussing the fundamental principles of operation applicable to both types, they have included much material on the smaller types of plants and their operation. All these are treated without the use of advanced mathematics. Approved methods of operating all equipment are outlined in detail and the responsibilities of the operating engineer for safe practice and efficient operation are carefully pointed out. Rules of procedure to be followed are given step by step.

The subject is treated in the following chapters: 1—Boilers; 2—Construction of Boilers; 3—Combustion of Fuels; 4—Settings, Combustion Equipment and Heating Surfaces; 5—Boiler Accessories; 6—Operation and Maintenance of Steam Boilers; 7—Pumps; 8—Reciprocating Steam Engines; 9—Valve Operating Mechanism; 10—Operation and Maintenance of Steam Engines; 11—Construction of Steam Turbines and Auxiliaries; 12—Operating and Maintaining Turbines and Auxiliaries; 13—Auxiliary Steam-Plant Equipment.

Several appendices contain data on engineering units, simple arithmetic, definitions of terms used in steam engineering and steam tables and charts. Appendix E shows how to calculate the stayed area of the heads of horizontal-return tubular boilers.

• • •

Mid-Century, The Social Implications of Scientific Progress, Edited by John Ely Burchard. First Edition; 551 pages; size 6¼ by 9¼ in.; cloth; published jointly by The Technology Press of MIT and John

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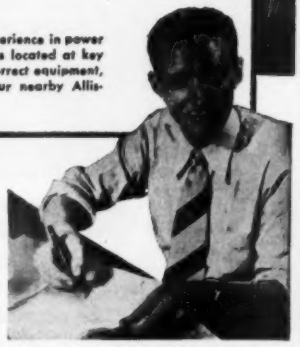

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DART UNIONS

Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.; 1950; price $7.50.

This book is a record of the papers and the discussion of them delivered during an international Convocation held at MIT during the spring of 1949 to explore some of the principal problems which have been raised by science for the twentieth century. Forty leading scholars and men of affairs met in this Convocation to exchange their views on this subject.

The book is a clear statement of the principal points of view of a number of our leading thinkers about problems involving man and his relation to the world he lives in today. These include ideas on the development and conservation of natural resources, technical assistance to undeveloped areas, the influence of science on man's faith, the role of the individual in modern society, specialized education for tomorrow, and how higher education shall be supported in the future.

The speakers included such figures as Winston Spencer Churchill, Karl T. Compton, Vannevar Bush, Ralph E. Flanders, Harold E. Stassen.

BURNING GAS

(Continued from page 71)

formly across the boiler, should be satisfactory. These holes pass only a small amount of hot gases when the boiler is in operation, which will not affect the over-all efficiency materially.

Some boilers, however, are so designed that they cannot be purged completely by placing holes in the baffle. In such a case, it is necessary to put two or three holes into the roof of the pocket, in addition to the baffle vents. Number of holes depends on boiler width. These ports or holes are connected directly to the breeching by a 2-in. steel pipe, with no shut-off valve in the line.

Installing Burners

The gas burner should be installed firmly in a position where it is readily accessible for inspection and cleaning. It should be so placed and so adjusted that the flame will not impinge directly on the boiler walls or on the heating surfaces. Impingement of the flame on the surfaces will result in incomplete combustion or in overheating of the pressure parts of the boiler.

All adjustable burner parts should be secured and kept secured with suitable locking devices so that they will not shift accidentally, and thus cause the flame to change its position. The burner should be kept so adjusted that complete combustion will be maintained not only at the minimum rate of firing but also during any modulating period between low and high firing rates.

There should be no vibration and no tube resonance as a result of burning gas.

Gas engineers find it preferable to space an odd number of burners across the furnace instead of an even number. The uneven number arrangement enables the power engineer to make up various combinations of burners for operation at partial load and still provide a uniform distribution of heat within the combustion space.

In natural-draft boilers, if the distance between the bottom and top

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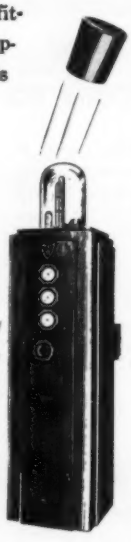


CD-31

burners will not be too great, the burners may be installed at two different levels. A distance of 2 ft between centers of the two rows of burners has been found satisfactory. When the distance between centers increases to 5 ft, difficulties arise in adjusting the two sets of burners due to the difference in draft conditions, because the upper set of burners shows a lower air-gas ratio than the bottom set. The difference is compensated for by closing the louvers on the bottom burners to increase the draft loss through them, so as to meet the draft conditions required by the upper burners. Naturally such difficulties are not met on forced-draft jobs.

The Gas Combustion Chamber

In determining the size of the combustion chamber for a particular job, consideration must be given to the exposed black surface and its influence on wall temperature. Boilers with a large area of black surface have a low combustion chamber temperature. They permit a higher heat release per cubic foot of chamber volume—without inviting refractory and tube troubles. Boilers with water-cooled walls have a lower furnace temperature and therefore permit higher heat release and greater capacity.

For brickset boilers equipped with multitube type and register type gas burners, combustion engineers have found to be satisfactory, in actual operation, a combustion chamber volume of 0.8 to 2½ cu ft per developed horsepower.

Horizontally baffled boilers, or rear-shot vertically-baffled boilers may be operated with a combustion chamber volume near the low limit of 0.8 cu ft per developed horsepower.

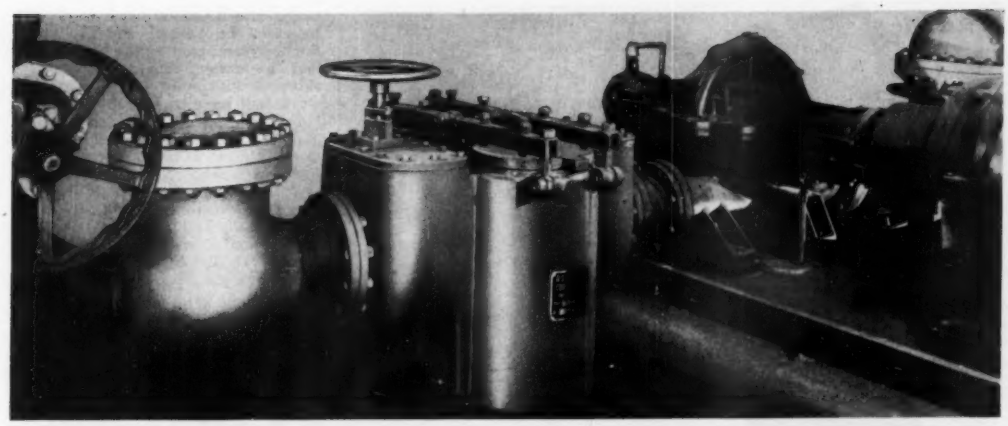
In some of the three and four-drum boilers, the combustion chamber volume should be large, because of the wide discrepancy between the actual combustion chamber volume and the useful volume. A space of 1½ to 2½ cu ft per developed horsepower is not too great.

Converting a Boiler to Gas

When gas burners are to be installed in a boiler, it may be desirable or necessary to remove the stoker, or grate, and if the waterback is taken out, the supply and return pipes will have to be removed and new tubes installed similar to the other boiler tubes. Or the openings of the tubes in the drums and headers will have to be closed with thimbles.

All re-entering or ignition arches or other devices used for promoting turbulence, and for controlling flame travel when firing with coal, are removed also. They are not needed in gas firing; and they tend to reduce the volume of the combustion chamber and the exposure area of the black surface.

After the furnace has been cleaned



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Valve is in continuous contact with the seat, and cannot become loose or fouled. Operating mechanism is on the downstream side of the strainer, not in the path of flow and in contact with clean strained liquid only.

R-S Strainers are widely used on house service lines in major generating stations and on fuel oil lines in utility and heavy industrial plants. Available in various types of metal for nearly all liquids in four-inch to 24-inch pipe sizes. Call your nearest R-S Engineer for further information or write direct.

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Designed for minimum pressure drop and low maintenance (only one stuffing box), the R-S Strainer was developed by a well known power plant piping design engineer in order to eliminate the disadvantages of most strainers for heavy industrial service.

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Calco has an outstanding boiler plant and here as in so many other important boiler plants, Green Fans carry the load. They're soundly designed and strongly made. They give satisfactory service. Look into their values for your fan requirements.

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out, a new floor and brick work will have to be placed in the space formerly occupied by the bridge wall and the stoker. Any portion of the sidewall that may be lost in this work will have to be replaced.

Concrete foundations, ash hoppers and dust collectors, found in most of the boilers to be converted to gas firing, will require protecton against fire box heat. Protection may be given by installing a ventilated floor consisting of 6-in hollow tile covered with a course of insulation and two courses of fire brick. It is a good plan to put ¼-in. asbestos millboard over the tile before laying the brick, to prevent possible infiltration of air into the furnace.

Some of the older, vertically-baffled, straight-tube horizontal type boilers may need additional protection of the walls. This can be given by facing the 4½-in. fire brick on the side walls, back of the bridge, with an additional 4½-in. fire brick wall.

For other types of furnace floor and wall construction, protection should be provided upon recommendation of the gas engineer or manufacturer's representative.

If a chain grate stoker is left in place, the opening to the hopper at the rear wall is closed. The stoker is protected by covering it with 2½-in. of insulating brick and 5 in. of fire clay brick. To stop filtration of air through cracks in the brickwork, the grate is covered with ¼-in. asbestos board before the brick is laid.

If an underfeed stoker is to be left in place, its retorts, which enclose the coal feeding mechanism, are usually filled with dry sand or cinders before the firebrick are laid.

Spreader stokers receive usually the same protection as chain grate stokers. But instead of covering them with firebrick, a thick layer of cinders may be used. However, infiltration of air through the cinder bed must be prevented by asbestos board or other means.

Combustion of Gas in Boilers

The theoretical complete combustion of gas without excess air requires 10 cu ft of air for each 1000 Btu of gas burned. Products of combustion will then be 1.0 cu ft of CO_2, 7.5 cu ft of nitrogen, and 2.0 cu ft of water vapor (0.048 lb per cu ft).

When CO and H_2 are present in the combustion product, the combustion is not correct. The power engineer must then increase the air supply, reduce the gas input, and improve the draft on the air and gas mixing process. The CO represents a loss in efficiency of combustion, and also a potential hazard; CO_2 levels ranging from 75 to 95 per cent of theoretical values are therefore suggested as a means of assuring ample but not excessive amounts of extra air. Good operating practice for gas equipment requires that no CO be present in the flue gases; the

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minimum acceptable is 0.4 per cent.

Small amounts of CO can be determined with accuracy by the power engineer when using a simple CO instrument manufactured by the Mine Safety Appliance Co. and the United States Testing Co. under license of the United States Bureau of Standards.

Efficiency of gas burning can be evaluated readily from an accurate determination of the average temperature of the flue gases and of their CO_2 content. Generally, 9 per cent CO_2 in the flue gases is accepted as satisfactory, but in the case of power burners the CO_2 content should be somewhat higher. See Table V.

Maximum CO_2 content of the flue gases should, on the basis of experience with boilers converted to gas firing, be limited to 10.5 per cent. This figure corresponds to about 10 to 20 per cent excess air in the flue products. On the basis of experience obtained over several years, with a CO_2 content ranging between 10 and 10.5 per cent at ratings up to 200 per cent, and with a normal amount of black surface, no excessive refractory maintenance will occur.

Gas engineers assume generally that flame temperatures in gas fired boiler settings are in the range of 1800 to 2400 F.

Heat input per square foot of black surface exposed to the radiant heat of the furnace can be safely as high at 260,000 Btu per hr, which corresponds to approximately 7½ hp. But to provide a safety factor for scaling, due to possible poor feedwater treatment or carelessness in operation, the heat input for use in actual boiler practice is often set at 7 hp per square foot of exposed tube surface. However, under most favorable feedwater treatment, inputs as high as 11 hp per square foot of exposed black surface have been practiced, with no tube failure. Such intense heat delivery means high furnace temperatures and increased maintenance. Therefore, it is preferable to follow the rule of 7 hp.

Black surface subjected to furnace radiation is determined by multiplying the exposed tube length in feet by the furnace width in feet and adding the projected area of any water-wall tubes, to obtain the total area.

ROBIN S. KERSH, formerly manager of central station sales for the Westinghouse Electric Corp., has been named manager of the company's Steam Division at South Philadelphia, Pa. The appointment was announced recently by David W. R. Morgan, vice president in charge of both the Steam and Aviation Gas Turbine Divisions. Mr. Morgan has been acting as manager of the Steam Division in addition to his other duties.

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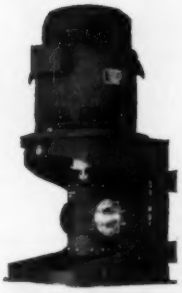

Both Screw and Rotex type pumps are available either horizontal or vertical mounted.

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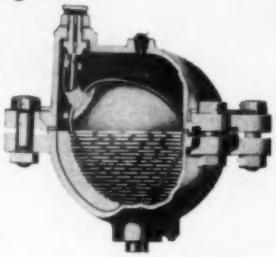

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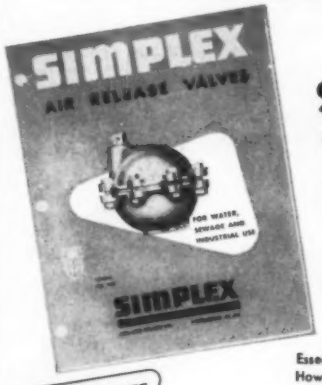

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SIMPLEX
VALVE AND METER COMPANY

HELPFUL BULLETINS

(Continued from page 50)

GT-250, on carbide tools and parts, covers all data in company's former tool catalogs and supplements as well as many new items. Book not only lists tools; it tells how to select and use them. Differences and even limitations in the various grades of carbide are clarified, not only for tool grades but also for wear-resistant grades, making it easy to select grade for practically any application. Discusses non-tool uses for carbide—tubing, shaped lengths, solid guide bushings, check valve seats, slotted guide rings. Full color illustrations are used profusely and there's a pictorial index. Technical literature offered by company is also listed. Carboloy Co., Inc.

125 Speedy Portable Saw—Illustrated Form 713, 2 pp, describes an air-cooled portable power saw which does hundreds of cutting jobs in wood and metal and other materials and needs no starting hole. Includes specifications, description of drills, blades and lubricant, also parts list. R. C. S. Tool Sales Corp.

126 How to Reduce Brush Costs—This 24-pp booklet is a recent edition of a deservedly popular handbook on the use and care of paint brushes. Illustrated throughout, it tells how to get the best use and longest wear out of paint brushes and includes step-by-step directions for proper cleaning. Includes a chapter on nylon brushes. Hanlon and Goodman Co.

OTHER EQUIPMENT

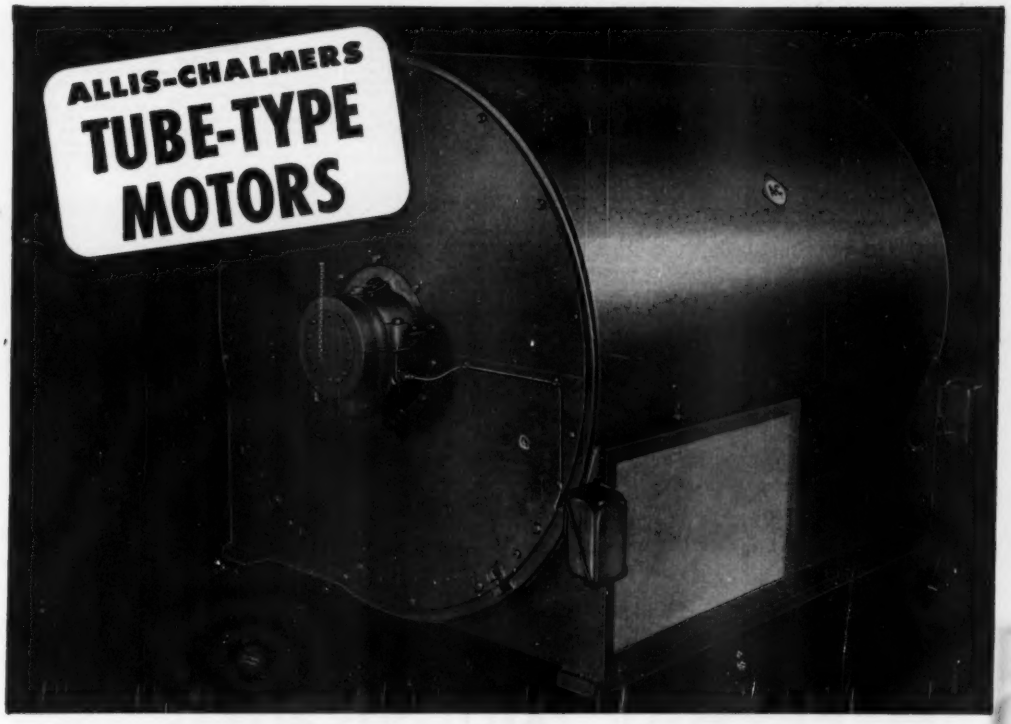
127 Insulating Materials—Form CDL-13 offers 12 pp of product and application data on electrical insulation materials and industrial laminates. Covers insulating varnishes, sealing and filling compounds, varnished cloth and tapes, silicone and mica insulations, laminated plastics. Tables show properties, recommended uses. General Electric Co.

128 Easier Machine Installation—Bulletin 415 describes low cost machine mountings that simplify machine installation, control vibration, reduce noise and absorb impact. Gives illustrated directions for installing pads, pictures their use with several types of machinery. The MB Mfg. Co., Inc.

129 Steel Flooring and Armoring—Sixteen-pp Catalog 1103 discusses different types of company's Tri-Lok open steel flooring and safety treads. Contains specification data, safe load tables, installation methods and other helpful information. Also included is a description of floor armoring and T-Tri-Lok flooring, the latter an assembly of tee bars which, when filled with concrete, is used instead of heavier floorings to reduce dead load and permit lighter weight superstructure. Machinery Div., Dravo Corp.

130 Demand Oxygen Unit—A new demand-type oxygen unit for emergency treatment of smoke inhalation, heart failure, carbon monoxide inhalation is described as to construction and operation in illustrated Bulletin CW-5, 2 pp. Self contained, the unit is put in operation by opening the cylinder valve and placing the facepiece on the patient. Oxygen is administered automatically as patient's breathing requires it, and this instrument is also suggested for use in conjunction with artificial respiration in cases of asphyxia. Mine Safety Appliances Co.

131 Spray Nozzle Systems—Recooling spray nozzle systems for use in plants operating condensers or using large quantities of water for cooling, are pictured and described in 8-pp Bulletin 6A-SP. It details design, application, construction, and operation of spray nozzles, and diagrams typical spray pond arrangements. Sizes, dimensoins, capacities, and spray nozzle patterns are included in tabular form for each nozzle size. A temperature graph gives cooling performance curves for spray nozzles for various temperature ranges using 7 psi at the nozzle. Atmospheric conditions and operating pressures are discussed. Bulletin also presents louver screens to prevent spray from being carried away by the wind while, at the same time, providing for maximum air passage. Schutte and Koerting Co.



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ALLIS-CHALMERS

CATALOG LIBRARY

(Continued from page 54)

and controlling fluid flow. Tells how these flow tubes are designed and how they function and discusses their advantages. Foster Engineering Co.

246 **Control Equipment**—General Catalog 001, 30 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pilot equipment. Simplex Valve and Meter Co.

247 **Pressure Regulator**—Bulletin 1-B, 8 pp, discusses design, operation and applications of a super-sensitive pressure regulator; shows typical installations. Also covers a compound regulator for controlling back pressure relief valve and high pressure make-up valve. Atlas Valve Co.

248 **Control Linkage**—General Specification CA942, 16 pp, presents control linkage for company's control drive and also contains engineering price data. Explains and illustrates flexible control design drive levers, driven levers, connecting links, bearings and shaft and cable, also rotation over 90 deg. Bailey Meter Co.

249 **Pressure Reducing Valves**—Selection and engineering data on pressure reducing valves, including those for remote control of reduced steam or water pressures, are presented in 12-pp Bulletin 477-A. Valve types are illustrated. Also described and illustrated is company's desuperheater. Northern Equipment Co.

250 **Index to Information** — Compiled to help power engineers obtain literature wanted on chemical proportioning equipment, volumetric and gravimetric feeders, and recording, indicating and control instruments, 4-pp Bulletin BIF-1 describes briefly 36 available bulletins covering this equipment. BIF Industries.

RODA

High grade gas, by-product, steam and household stoker coal from Wise County, Virginia, on the Interstate Railroad.

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PUMPS, COMPRESSORS, ENGINES

251 **For Many Pumping Jobs**—The Series A313A, latest of company's well-known IMO pumps and especially designed for low cost standardized, quantity production, is described in illustrated Bulletin L313A-B, 8 pp. This is a general service screw-type rotary pump for petroleum products and other light or viscous fluids as required for rotary and steam atomizing oil burners, oil transfer, lubrication, hydraulic systems and similar services. De Laval Steam Turbine Co.

252 **Compressor Selection Chart**—Here's a selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Worthington Pump and Machinery Corp.

253 **Air Compressor Lubrication Manual** —Valuable information on air compressor maintenance is contained in this 40-pp illustrated book. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements, operating hints, oil requirements, storage and care of compressor oils, and safety precautions. Cities Service Oil Co.

254 **Modern Steam Engines**—In presenting steam engines as more than "just drives," Bulletin 306 touches briefly upon some of the advantages of "by-product" power. Bulletin features company's vertical steam engines of both throttling and automatic governor types. Troy Engine & Machine Co.

255 **Boiler Feed Pumps**—Bulletin 109, 16 pp, illustrated in color, describes in detail centrifugal pumps for boiler feed service. Explains and pictures construction and major parts, explaining in detail the floating seal incorporated. Capacity data is provided, also vapor pressure tables. Pacific Pumps, Inc.

256 **Pulsation-Free Compressor Piping**—Illustrated Bulletin PDS-8501, 4 pp, describes company's pulsation dampening piping system. Tells how this piping compares in first cost to other piping, but affords higher operating efficiency, improved flow measurement and lower maintenance costs. Explains pulsation phenomena in gas compression systems and how dampening principle is applied. The Fluor Corp., Ltd.

257 **Centrifugal, Reciprocating Pumps**—This is a helpful collection of bulletins covering many types of centrifugal and reciprocating pumps for a wide range of services. Includes data on single-stage and multi-stage pumps, close-coupled pumps, high pressure pumps, pumps especially suited for handling erosive and corrosive liquids and others. Warren Steam Pump Co., Inc.

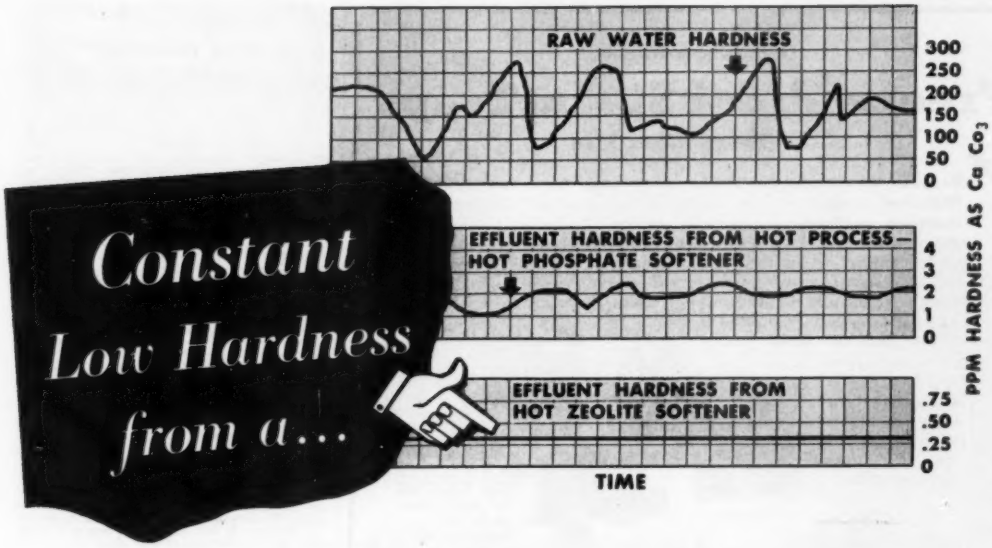
ELECTRICAL

258 **Power Factor Correction**—Examples illustrating basic considerations in the improvement of system power factor are contained in Bulletin 05B7465, 4 pp. It points out economical and operational advantages of improving plant power factor and advisability of keeping the load power factor up to 0.8 lagging or higher, and tells how the effects of low power factor can be corrected. Allis-Chalmers Mfg. Co.

259 **Synchronous Motors** — High speed synchronous motors are described in 4-pp bulletin PB 5600-1. The bulletin is packed with descriptive matter and photographs explaining features. Elliott Co.

260 **Low-Speed Synchronous Motors** — Publication GEA-5332, 8 pp, illustrates typical installations of efficent high-power factor, constant-speed drives, describes their construction features, and indicates mechanical modifications and performance data. General Electric Co.

261 **Care of A-C Rotating Equipment**—To promote intelligent and consistent maintenance of electrical machines, company has published Bulletin 05R7417, which is a series of articles by Fraser Jeffrey. Contents of the 24-pp booklet cover preventive maintenance and machine repairs, and such subjects as drying moist



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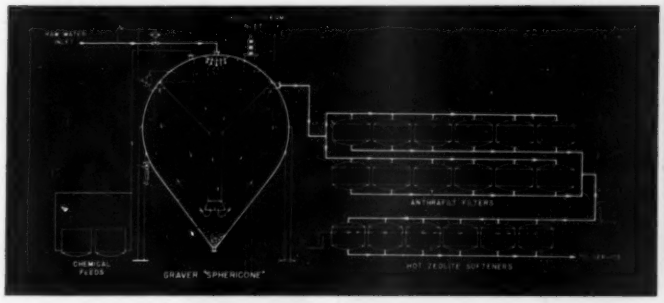

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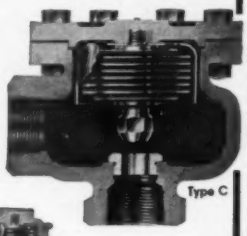

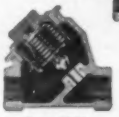

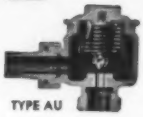

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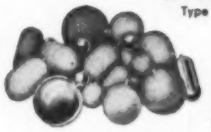

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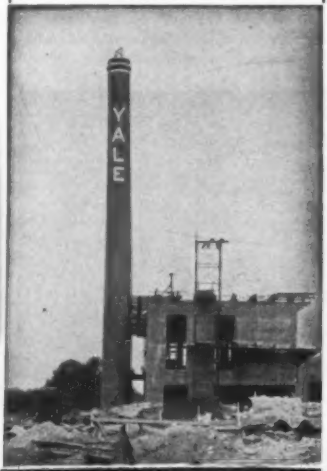

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insulation, measuring insulation resistance. Allis-Chalmers Mfg. Co.

COAL HANDLING

262 **Spreader Stoker** — Bulletin 890, 40 pp, describes a spreader stoker with overthrow rotor designed to provide uniform fuel distribution. Discusses advantages of this type of stoker, including its efficiency in the burning of many grades of coal and in handling of fluctuating loads. Power-operated and hand-operated dumping grates and stationary grates are described and illustrated. Book includes photos of installations. Detroit Stoker Co.

263 **Coal Handling Equipment**—Modern equipment for the storage and handling of coal and ash is presented in 24-pp Bulletin 300. Illustrated, covers concrete and tile silos, cylindrical steel tanks, suspended steel bunkers. Gifford-Wood Co.

264 **Spreader Stoker Selection** — Fourteen-pp Form P-320-A10M is intended to help those choosing a spreader stoker to get the most for their investment, and it points out many factors to be considered. American Engineering Co.

265 **Spreader Stoker Data**—This is a file of three illustrated bulletins on spreader stokers. The first discusses seven reasons for selecting these stokers and describes their design, construction and operation; the second, dumping grates, the third, installations. Riley Stoker Corp.

266 **Coal Scale Manual** — Recently-published Bulletin 0150 describes automatic coal scale construction and operation, illustrating special design features which provide for high accuracy and long service. Richardson Scale Co.

FUEL OILS, LUBRICANTS

267 **Diesels, Their Fuels and Lubricants** —This 46-pp book offers a well organized and attractive presentation of practical information on diesel engines, covering their history and economics as well as their design characteristics and operating principles. Classification of diesels according to speed is explained. Other chapters cover injection systems, combustion chambers, lubricating systems, and deisel oil purification and filtration. Includes a discussion of fuel and lubricating oil required. Sinclair Refining Co.

268 **Fuel Oil Treatment** — By text and sketches, this folder points out undesirable conditions in the storing, pumping, heating and burning of industrial fuel oil and the correction of these conditions by company's fuel oil treatment. E. F. Drew & Co., Inc.

269 **The Answers on Turbine Oil**—This 2-pp booklet answers several questions power engineers ask about turbine oils, including: What causes deposits of sludge? What causes acidity increase? What causes corrosion in turbines? Standard Oil Co. (Indiana).

270 **Grease Application Devices**—The development and use of many types of lubricating devices are discussed in an excellent article in Vol. 36, No. 9 of Lubrication, company's technical publication on lubricants. Covers the pressure gun, spring type grease cups and several types of power driven grease lubricators, explaining such points as the judicious use of pressure measured lubrication, pumpability characteristics of lubricants. The Texas Co.

METALS

271 **Engineering Data on Inconel** — In addition to providing extensive information on Inconel, 24-pp Bulletin T-7 also presents details on the composition, mechanical properties and physical constants of Inconel X. The International Nickel Co., Inc.

272 **Steels for Hot Spots** — This is an 88-pp manual filled with information on steels for elevated temperature service. Includes a discussion of the general principles of high temperature behavior of ferrous materials and the factors influencing their behavior; a data section replete with tabular and graphical material covering mechanical property values of 21 steels. United States Steel.

CONDENSERS

273 **Condensers** — Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Photos and drawings show as-

WHERE TO USE LUMNITE IN POWER PLANTS

Steel Stack Linings

Ash Pit and Cinder Catcher Linings

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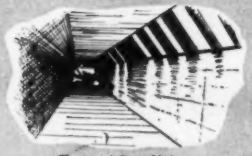
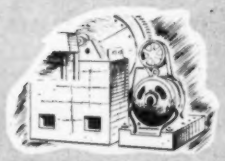
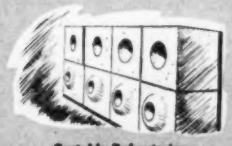


Flue and Duct Linings



Overnight Structural Concrete



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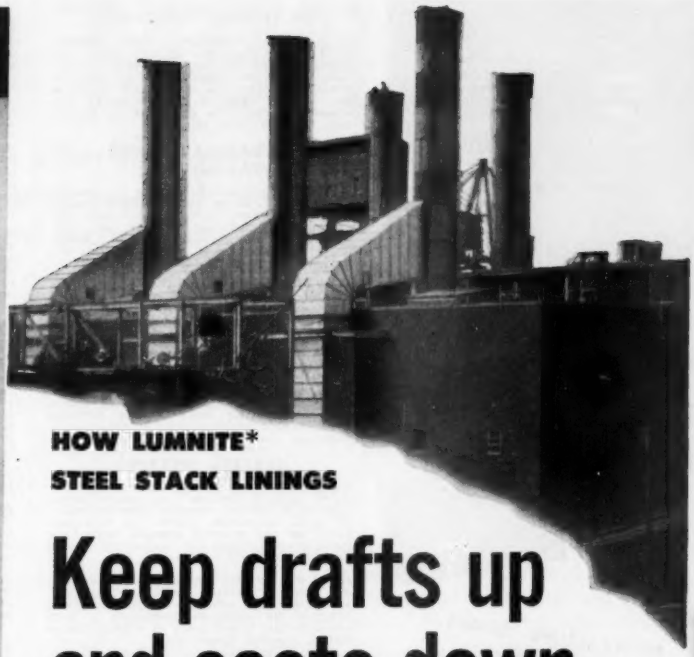

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Drafts will stay up in these five National Tube Company steel stacks. Smooth, jointless Lumnite refractory concrete linings offer less resistance to gases, prevent "breathing," and their insulating qualities keep gas temperatures high.

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PE-L-43

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assemblies, parts, principles of operation. Condenser Service & Engineering Co.

274 **Steam Condensers with Reverse Flow** — Eight-pp Catalog 410-1 describes a "self-cleaning" reverse-flow condenser for power plant service, designed to virtually eliminate cleaning down time and, in the case of divided water box condensers, eliminate operation at partial load. C. H. Wheeler Mfg. Co.

MECHANICAL POWER TRANSMISSION

275 **Transmission Belting** — Catalog M-0922, 28 pp, gives detailed design, engineering and performance data on transmission belting. Tables on belt speeds, arc of contact, friction, horsepower correction, and service factors are included. United States Rubber Co.

276 **Hydraulic Couplings** — Bulletin 3924 is Vol. II of "Progress in Power," a 24-pp collection of advertisements covering use of hydraulic couplings in power plants. American Blower Corp.

277 **Worm Gear Drive Manual** — Engineering and ordering data on company's worm gear drives is presented in 52-pp Book 2324. Illustrated with photos and sketches it discusses types of drives and construction features and provides selection tips. Provides ratings, dimensions, overhung and thrust loads. Link-Belt Co.

HEATERS, HEATING

278 **Water Heaters**—Illustrated 6-pp Bulletin 70, Section I, on instantaneous type water heaters contains detailed capacity and dimension tables for two-pass, four-pass and six-pass designs, with tube bundles removable for inspection. Davis Engineering Corp.

279 **Fan Heater Bulletin** — Here's a 2-pp illustrated bulletin (No. 109) on a new high pressure steam fan heater designed for complete utilization of both sensible and latent heat of high pressure steam. Niagara Blower Co.

280 **Heat Exchangers** — Bulletin 11.0.080 describes air cooled heat exchangers for condensing or cooling of steam or process vapors, natural gas, jacket water, lubricating oil, quenching baths. Equipment Div., J. F. Pritchard & Co.

281 **Tubular Heat Exchangers** — Bulletin 916, 32 pp, describes tubular heaters, coolers, condensers and heat exchangers and their features. The various types of shells, tube bundles, stationary heads and floating heads are explained. Includes tables showing characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and API. Also presents charts of specific heats of midcontinent crudes. Griscom-Russell Co.

DUST COLLECTING

282 **Fly Ash Elimination** — Power engineers will find this 30-pp booklet outstanding among material on this subject. It presents manufacturer's "Multiclone" equipment (described as small-tube type of cyclonic dust collectors using centrifugal force for separating duct from gas stream) as a highly successful and economical means of separating fly ash—not as a panacea for all cinder and fly ash problems. Western Precipitation Corp.

283 **Dust Collecting Efficiency**—How the higher and narrower inlet utilized in company's tubular dust collector contributes to more efficient dust collecting is explained in this illustrated bulletin. Prat-Daniel Corp.

PACKINGS

284 **Pump Packings** — Packings for use on reciprocating and centrifugal pumps are illustrated by photo and described in this 4-pp folder. It covers packings for practically all services and includes recommendations. Johns-Manville.

285 **Teflon Packings**—Form AD143 offers 8 pp of product information on packings and gasketing material made of Teflon, giving their properties, typical and special applications. Available styles and types are pictured, their construction described and sizes given. Includes chapter on the toxicology of Teflon at extremely high temperatures. The Garlock Packing Co.

286 **Manual on Packings**—Containing 84 pp of helpful engineering and ordering information, Catalog 40 covers packings for practically every service. Illustrates each type, gives sizes, construction and application details. Includes packaging recommendation charts, conversion tables. The Belmont Packing & Rubber Co.

OTHER EQUIPMENT

287 **Turbine Catalog Collection**—This is a valuable collection of bulletins covering a complete description of solid wheel turbines. They feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also includes data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

288 **Velocity Stage Turbines** — Catalog 82-19R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives specifications, dimensions. De Laval Steam Turbine Co.

289 **Fundamentals of Hydraulics**—Technical Bulletin B-4 is a newly revised 44-pp guidebook covering essential information on hydraulic systems, maintenance, trouble-shooting and selection of proper fluids. Besides offering well-organized reference data to engineering personnel, this book is suggested as a training manual for maintenance supervisors, operators and apprentices. It features specially prepared phantom and cutaway drawings illustrating functions of basic types of valves, pumps, hydraulic motors, torque converters. Shows function of each component part. Sun Oil Co.

290 **Ash Handling Systems**—This 24-pp illustrated booklet offers technical information on hydraulic and pneumatic ash and flyash handling systems. Compiled in question and answer form, it discusses elements and advantages of various systems and disposal schemes. Schematic drawings of arrangements under specific conditions and diagrams of basic arrangements are included. Beaumont Birch Co.

NEWS *from* THE FIELD

DAVIS HYDRO PLANT STARTS FIRST 45,000-KW UNIT

First of the five 45,000-kw hydroelectric generators at the Bureau of Reclamation's Davis power plant was placed in operation January 5. Operating intermittently during the following 7 days, while construction crews completed finishing touches and tests, the new unit was turned over to the Bureau's operating and maintenance forces on January 12.

Davis power plant on the Colorado river between Nevada and Arizona, 34 mi west of Kingman, Arizona, and 67 mi downstream from Hoover power plant, is the fourth largest hydroelectric power plant of the Bureau. The power plant will be generating to its full installed capacity of 225,000 kw next summer when all of the units are to be in operation.

The beginning of power production at Davis power plant is in time to be of material aid to the irrigation farmers in the southwest. Integrated by a 230-kv line with the Bureau's Parker power plant, 88 mi downstream, the generation of first power at Davis is also of particular importance at this time during the nation's greatly expanding defense effort.

Davis dam itself, an earth- and

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(Age-hardened)

Yield Point	80-115,000 psi
Tensile Strength	120-145,000 psi
Elongation in 2-in.	4-1%
Hardness (Brinell)	300-375
Coefficient of Thermal Expansion (32°-212°F.) in./in./°F.	.0000068

Hardness of "S" Monel at Elevated Temperatures*

(As-cast condition)

Temperature, °F.	Brinell Hardness
Room	321
700	321
800	311
900	311
1000	321
1050	335
1100	293

*Average properties—not to be used for specification.

Hardness: "S" Monel can be age-hardened to 300-375 Brinell. It retains this hardness even at elevated temperatures. (See table.)

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Weldability: "S" Monel is *not* recommended as a weldable material.

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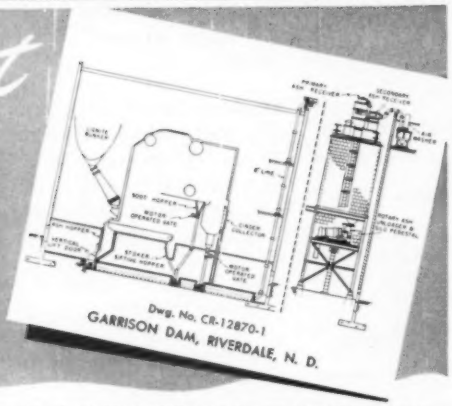

At the GARRISON DAM, RIVERDALE, NORTH DAKOTA, this Beaumont installation handles lignite ash and soot with a steam actuated Vac-Veyor System. Under this system, clogging of the venturi and resultant shut-down have been eliminated. Also, as shown above, the air washer is located inside the boiler house; this prevents the water from freezing during North Dakota's sub-zero winter . . . Whether your material handling problem is unusual or not, write today for prints of typical Beaumont installations.

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DESIGNERS—MANUFACTURERS—ERECTORS BULK MATERIAL HANDLING SYSTEMS

rock-fill structure 138 ft high above the riverbed and 1600 ft long, is completed. The outlets at the dam were closed on November 24, 1950, and all water now released passes over the spillway crest or through the power plant.

Davis dam is the last of the major Reclamation dams that are to be built below Hoover dam in the presently-planned development of the river, for it utilizes the last major power drop of this section of the river.

THREE DISTRICT MEETINGS OF AIEE THIS SPRING

THREE district meetings of the American Institute of Electrical Engineers are scheduled for April and May, according to an announcement today by H. H. Henline, Institute Secretary. The three precede the Summer General Meeting of the Institute at Toronto, Canada, June 25-29.

The Southern District meeting is scheduled to be held April 11-13 at Miami Beach, Fla. Included in the district are the states of Kentucky, Virginia, Tennessee, North and South Carolina, Louisiana, Mississippi, Alabama, Georgia and Florida.

Syracuse, N. Y., will be the scene of the three-day North Eastern District Meeting, May 2-4, with engineers and scientists from the following states: New York, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, and Maine.

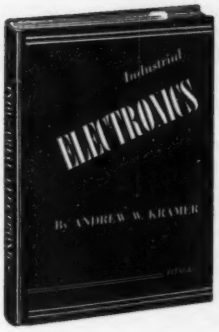
The Great Lakes District meeting will be held May 17-19 in Madison, Wisc. The district includes the states of Minnesota, Iowa, Wisconsin, Illinois, Michigan, Indiana, North Dakota, and a large part of South Dakota.

FIFTY PER CENT OF WORLD'S COAL RESERVES IN NORTH AMERICA

IN A RECENT GEOLOGICAL SURVEY, the Department of the Interior estimated that the nation's reserves of recoverable coal totaled one and one-fifth *trillion* tons—enough to build a coal pile five miles high and fifty miles in circumference.

When this figure was released, the Secretary of the Interior, Oscar Chapman, asserted the coal was "one of the foundations" of our national security. And it could well be added that no other nation has such great security in coal. According to the Bureau of Mines, fifty per cent of all the coal reserves on earth are in North America. This largely explains why the world's "free" nations have a three-to-one advantage in coal over the "iron curtain" countries.

J. J. LLANSO has been appointed general export manager of Worthington Pump and Machinery Corp.,



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OTHER USEFUL BOOKS FOR ENGINEERS

USEFUL IDEAS FOR POWER ENGINEERS — A "how" book by the editorial staff of Power Plant Engineering furnishing hundreds of ideas on boilers, stokers, fuels, boiler operation, boiler water, refrigeration operation and maintenance, mechanical power transmission.

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BOILER FIREMAN'S HANDBOOK— by Joseph R. Darnell, provides boiler firemen and power plant engineers with accurate, dependable data for solving many combustion problems. It also offers many helpful suggestions for the successful operation of various pieces of apparatus found in the power plant.

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according to an announcement by S. R. Williams, vice president in charge of foreign business. Since 1947 Mr. Llanso has been a vice president and manager of Worthington Ltd., Buenos Aires, Argentina.

THE PURCHASE of all the physical assets of Canadian Allis-Chalmers, Limited, by a new wholly owned subsidiary of Allis-Chalmers Manufacturing Co. of Milwaukee, Wisconsin, was announced today by the parent concern. The new subsidiary is known as Canadian Allis-Chalmers (1951) Limited. The Canadian firm, which employs approximately 525 people, will continue the production of heavy machinery for the Canadian market. M. C. Lowe, formerly vice president of Canadian Allis-Chalmers, Limited, has been named president of the new Allis-Chalmers subsidiary.

RALPH E. DONNELLY of Fitchburg, Mass., has been appointed manager of the General Electric Company's Fitchburg Turbine Sales Division, according to an announcement by C. S. Coggeshall, Turbine Division's sales manager. Mr. Donnelly was assistant manager of the division until his present appointment.

A NEW CHICAGO district office has been established by Hagan Corp., Pittsburgh combustion and chemical engineering firm, and its subsidiaries, Hall Laboratories, Inc., Calgon, Inc., and The Buromin Co. The office is at 1463 Monadnock Building, 53 W. Jackson Blvd., Chicago 4. The Hagan Corp. was formerly represented in Chicago by Burke & Colston.

D. ROBERT YARNALL, President of Yarnall-Waring Company, was awarded honorary membership in The Engineers' Club of Philadelphia at the Club's recent Mid-Century Dinner Meeting. There have been only 25 such memberships awarded in 73 years of the Club's existence.

CARROLL V. ROSEBERRY has been appointed manager of the central station department for the Westinghouse Electric Corp., it was recently announced by Tomlinson Fort, manager of apparatus sales. Mr. Roseberry succeeds R. S. Kersh, who has been named manager of the Company's Steam Division at South Philadelphia, Pa.

CHESTER H. BUTTERFIELD, vice-president and general manager of the Consolidated-Ashcroft-Hancock division of Manning, Maxwell & Moore, Inc., has appointed Robert E. Mason as director of mobilization planning for the division and Leslie T. Willard as works manager of the combined Bridgeport and Stratford, Conn., plants.

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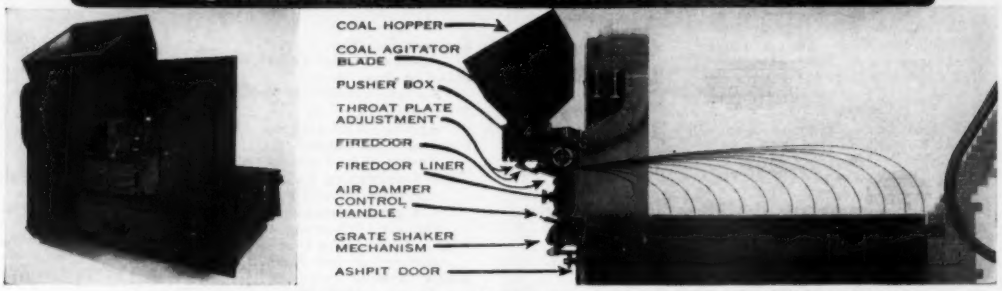
SPREADER STOKERS



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ENGINEERING MANPOWER NATION'S NO. 1 PROBLEM, SAYS COMPTON

(Continued from page 75)

derground cable. The Commonwealth Edison Co. (Chicago), he said, had increased its capacity by 28 per cent, with normal 75-80 F operation. Transformer ratings, too, he said, had been increased as high as 185 per cent. Adding up the influence of all the cable people had done, he felt that they had been able to counteract the greatly increased cost of labor and materials.

Undersea Cable Technique

With respect to developments in cable technique, one of the most interesting had nothing to do with power transmission. It concerned the new undersea telephone cable between Key West, Florida, and Havana, Cuba. This is the first deep-sea cable equipped with self-contained amplifiers. This 115-mile cable is of the coaxial type and its built-in vacuum tube amplifiers are spaced about 40 miles apart. They rest on the ocean floor as much as a mile below sea level. Actually two such cables were laid, one to carry the northbound transmission and the other for the reverse direction. Together, they provide 24-high quality talking paths. The cable's unique feature—building the amplifiers into the cable itself inside a specially constructed cylinder—resulted from a long range project at Bell Laboratories. The development called for the application of many new techniques, most of them requiring an unusually high degree of precision. These included fabrication of vacuum tubes capable of functioning, unattended, for perhaps as long as 20 years and their incorporation into a cable of sufficient flexibility for deep water laying, yet rugged enough to withstand the tremendous pressures encountered over a mile down on the ocean floor. Not the least difficult was the laying of the cable itself. The cable ship "Lord Kelvin" was modified in several ways to lay out the heavy cable smoothly without subjecting it and the delicate amplifiers to unusual stresses. The amplifiers are about 30 ft long. At the points where they are located, the cable bulges from its ordinary diameter of about an inch to approximately three inches for a distance of about 25 feet.

Economics and Calculating Machines

The electric calculating machines continue to hold their own in point of interest at the AIEE conventions. Of particular interest at this meeting was a paper by three Northwestern University engineers, R. H. Strotz, J. F. Calvert and N. F. Morehouse, on the application of the analog computer to the solution of economic problems. Over the past 15 years, the word *model* has become as prominent in the writings of economists as the word *circuit* in the works of electrical engineers. Both models and circuits may be described by mathematical relationships. Some of the analogies made by the authors of the paper were the interpretation of *price* as *potential difference; diodes* to prevent reverse current flow to represent the economic thought that consumers would sell goods back to the company, a *loop* beneath a condenser to represent the long run policy of maintaining inventories at a fixed level.

A novel automatic electronic machine developed by the National Bureau of Standards was described in a paper by H. M. Joseph of the Bureau of Standards. This is a machine for counting *old* paper money at the U. S. Treasury. Removing worn-out bank notes from circulation before substituting new ones involves the redemption of some 8 tons of currency every day. The bulk of this—about 5 million dollars worth—consists of one dollar bills. While new paper money has been machine counted for many years, the mechanical handling of worn-out notes has been a difficult problem. Now, the Bureau has developed a machine which accomplishes this. Money is returned to the Treasury in stacks of 100 notes, cut in half lengthwise. These are fed into the counter. When the latter is turned on, a metal finger pulls a packet of 100 half notes into the machine. The stapled end is grasped by metal jaws and the packet is wrapped tightly around a spindle, spreading the outer edges of the notes against a curved metal plate. The spindle then rotates the ends of the notes while a jet of air separates the notes from the packet. The counting is achieved by using an electronic sensing device, consisting of a beam of light and a photoelectric system. The counter counts 30,000 bills per hour.

Difficulties in the development of very high voltage transmission systems were disclosed at a session on Transmission where the experimental 500,000 v line at Tidd Power Station was discussed. Rain, sleet, and fog are proving the most formidable enemies to engineers striving to raise transmission voltages to 500,000 v. Power leakage caused by this "wet blanket" may be as high as 80 times the loss during fair weather.

These are but a few of the many interesting developments considered at this AIEE winter meeting. In subsequent issues, some of the more important papers of interest to power engineers will be abstracted in detail.

During the course of the meeting, Fred O. McMillan of Oregon State College was nominated for President of the Institute to succeed Titus LeClair at the end of his administrative year in July of this year.

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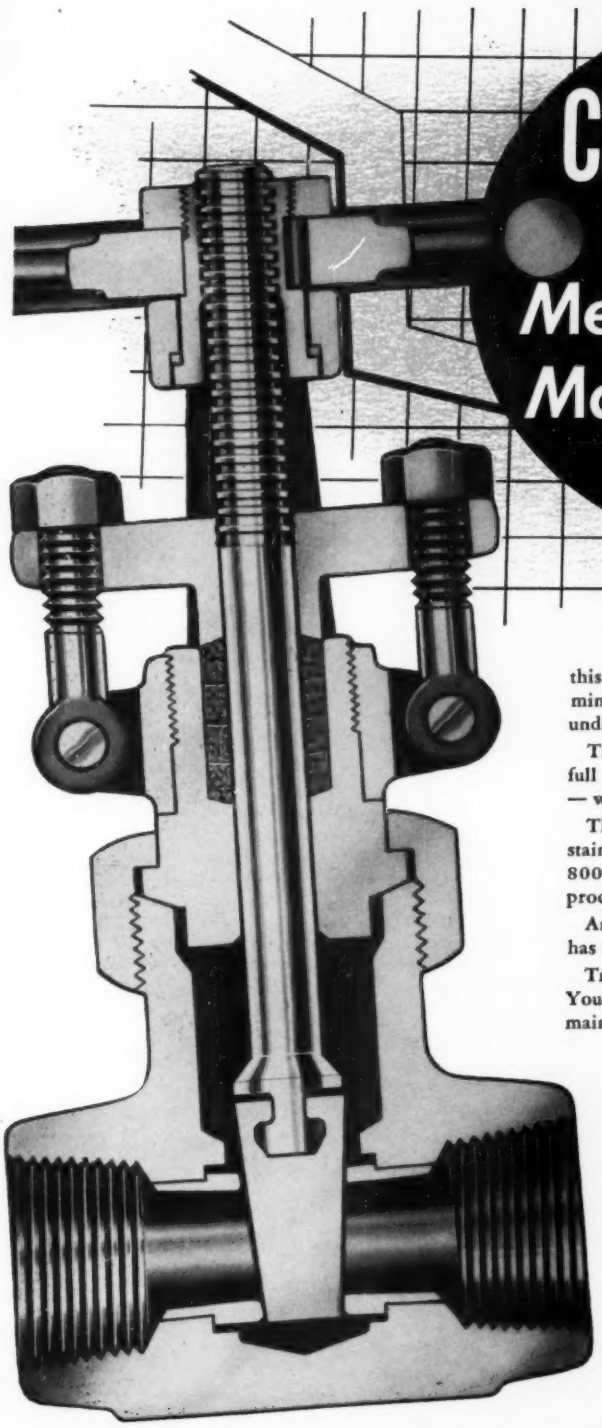

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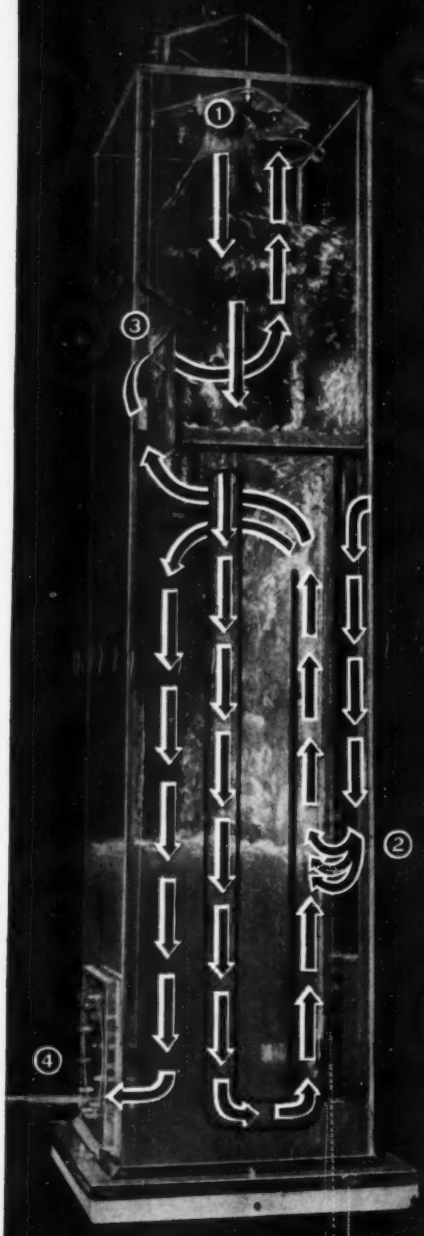

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